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The Elisha Mitchell Scientific Society

Founded in 1883 through the efforts of Francis Preston Venable

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R. L. INGRAM, Vice-President

E. T. BROWNE
Corresponding Secretary

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JOURNAL
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Elisha Mitchell Scientific Society

Volume 69 December 1953 No. 2

PROCEEDINGS OF THE FIFTIETH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

The fiftieth annual meeting of the North Carolina Academy of Science was held at North Carolina State College of the University of North Carolina. Raleigh, on May 8 and 9, 1953.

The Academy met in its first session at 10:00 a.m. on May 8 with President Otto Stuhlman presiding. A Symposium on The Use of Isotopes in Biological and Medical Research was presented at this session.

The business meeting of the Academy was held at 4:30 p.m. at which the following business was transacted:

The minutes of the 1952 meeting were approved as published in the Journal of the Elisha Mitchell Scientific Society **68:** 115-149.

Report of the Executive Committee

The Executive Committee met in Raleigh on May 8 at 3:00 p.m. At this meeting the following matters were considered:

1. The committee discussed the possibility of organizing a Collegiate Section of the Academy and recommended that the Secretary proceed to enlist the cooperation of interested Academy members with the view to holding a meeting of a Collegiate Section at the 1954 meetings if possible.
2. It voted to pass on to the new Executive Committee a proposal that the Academy investigate the possibilities of developing TV programs for use over the new Raleigh station and perhaps others in the state also.
3. The following were elected to membership in the Academy or reinstated to active membership:

Adams, Dr. Marguerite M., Shaw University
Andrews, James N., Mocksville
Baptiste, Sister Mary Jean, St. Patrick's Convent, Charlotte
Barber, Albert A., Zoology, Duke University
Barnes, Robert D., Zoology, Duke University
Barnes, Mrs. Robert D., Zoology, Duke University
Baumgartner, Mary Wanda, Meredith College
Bell, Thomas A., Raleigh
Biggs, Joseph Daniel, U. S. National Museum, Washington, D. C.
Bivens, Betty L., Salisbury
Borchers, Edward A., Horticulture, N. C. State College

Branca, Albert A., Veterans Hospital, Fayetteville
Brown, Charles Q., Geology, Univ. of North Carolina
Brett, Dr. Charles H., Entomology, N. C. State College
Bruce, Robert A., Amalgamated Chemical Corp., Philadelphia
Canaday, Dr. E. F., Meredith College
Carter, William G., Davidson, N. C.
Carter, Rev. William H., Goldsboro
Channell, R. B., Botany, Duke University
Cochran, Dr. Fred D., Horticulture, N. C. State College
Councill, Richard J., N. C. Dept. of Conservation and Development, Raleigh
Cutter, Dr. Victor M., Woman's College, U. N. C.
Davis, Morris Schuyler, Physics, University of North Carolina
Dawson, J. LeRoy, Pleasant Garden
Dieter, Donn Louis, Kinston
Dietz, Dr. James H., Horticulture, N. C. State College
Drolsom, Dr. Paul Newell, Tobacco Experiment Station, Oxford
Earp, G. J., Traphill
Etchells, Dr. John L., N. C. State College
Evans, Dr. Harold J., Botany, N. C. State College
Faller, Sister M. Joan, Sacred Heart Junior College, Belmont
Flowers, John Morgan, Atlantic Christian College, Wilson
Funderburg, John B. Jr., Wilmington
Freeman, Miss Claire E., Raleigh
Galloway, Carl W., Raleigh
Gangstad, Dr. Virginia, Women's College, U. N. C.
Gardner, M. E., Horticulture, N. C. State College
Gerstel, Dr. Dan U., Agronomy, N. C. State College
Green, Miss Cora Lillian, Yadkinville
Hall, Miss Anne H., Greensboro
Handler, Dr. Philip, Biochemistry, Duke University
Hansen, Dr. Ethel B., Flora Macdonald College, Red Springs
Harton, Frank N., Charlotte
Harvey, Dr. Paul H., Agronomy, N. C. State College
Harward, Dr. Moyle E., Agronomy, N. C. State College
Hatley, Raymon C., Oakboro
Haynes, Dr. Frank Lloyd, Horticulture, N. C. State College
Hedblom, Robert E., Physiology, Duke University
Higgins, Mrs. Eloise W., Greensboro
Hunter, Charles E., Asheville
James, Charles William, Botany, Duke University
Jeffreys, Donald B., Botany, University of North Carolina, Chapel Hill
Johansen, Mrs. Eloise L., Raleigh
Jones, Dr. Ivan D., Horticulture, N. C. State College
Jordan, Walter E., Chemistry, N. C. State College
Keefner, Robert, Huntersville
Khairallah, Dr. Philip A., Roosevelt Hospital, New York
Kohn, Dr. Hedwig, Physics, Duke University
Kraycirik, M. M., Catawba College, Salisbury
Lancaster, Robert W., Union Grove
LaNier, Miss Julia E., Poplar Branch
LeVesconte, Dr. Amy, Flora Macdonald College, Red Springs
Lineberry, Dr. R. A., Raleigh
Lineweaver, John R., Chapel Hill

Long, W. Henry, Entomology, N. C. State College
Lowenbach, Dr. Hans, Duke University Hospital, Durham
Lynch, Victor J., Asheville
Manly, Jethro, Botany, Duke University
Maroney, Samuel R., Durham
Maturo, Frank J. S., Jr., Zoology, Duke University
McClung, Dr. A. Colin, Agronomy, N. C. State College
McCutchan, Dr. K., Greensboro
McIntyre, Robert A. Jr., Zoology, Duke University
McNeely, Miss Jean A., Mooresville
Maureen, Sister, O'Donaghue School, Charlotte
Medlin, Dr. Gene W., Wake Forest College
Miller, E. L. Jr., Raleigh
Nease, Mrs. Pauline L., Durham
Perry, H. S., Botany, Duke University
Philpott, Dr. Jane, Botany, Duke University
Pigford, James M., Wilmington
Pope, Dr. Daniel T., Horticulture, N. C. State College
Porter, Dr. John C., Duke University Medical School
Reynolds, Dr. Lee F., Boone
Reynolds, William J., Winston-Salem
Russell, William John M., Salem
Sasser, Dr. Joseph N., N. C. State College
Schmidt-Nielsen, Dr. Bodil, Zoology, Duke University
Schmidt-Nielsen, Dr. Knut, Zoology, Duke University
Scott, Mrs. Gertrude G., Goldsboro
Scott, Dr. Percy C., East Carolina College, Greenville
Simpson, Booker Tallifero, A. & T. College, Greensboro
Simpson, Dr. Thomas W., Winston-Salem
Smith, Garmon B., Raleigh
Smith, Miss Odell Virginia, Greensboro
Steel, Warren G., Raleigh
Stepp, William L., Winston-Salem
Taylor, Miss Lena, Wilmington
Vanderau, Miss Margaret, Chemistry, Bowman-Gray School of Medicine, Winston-Salem
Volk, Richard J., Agronomy, N. C. State College
Ward, Calvin L., Zoology, Duke University
Webb, Alexander Grady Jr., Chapel Hill
Wells, Dr. Warner, School of Medicine, University of North Carolina
White, Booker T., A. & T. College, Greensboro
Williams, Austin B., Institute of Fisheries Research, Morehead City
Wills, Wirt H., Botany, Duke University
Withers, John P., Morton-Withers Chemical Co., Greensboro
Zimmerman, Dr. Bernhard G., Zimmerman Associates, Guilford College

4. The Secretary reported the following losses in membership:

1. By resignation: 7
2. By non-payment of dues: 65
3. By death the following:
   James L. Lake
   Charles McGee Heck
   William Basil Fox

5. The Committee recommended for life membership the name of S. W. Hoffman who, at this meeting, has completed fifty years of membership in the Academy.
6. The Committee accepted the invitation of East Carolina College to meet in Greenville in 1954.

The above reports and actions of the committee were approved by the Academy in its business session on May 8, 1953.

TREASURER'S REPORT

Financial Statement as of September 5, 1953

Receipts		
Checking Account balance (from September 22, 1952)		$145.96
Gifts		
Ornithology Essay Award		20.00
N. C. Section A.C.S.		10.00
A.A.A.S. Research Fund		195.00
Chemistry Prizes, High School Exhibits		40.00
Derieux Award		50.00
Dues, 1951, 1952		17.00
Dues, 1953		1186.50
Total		1664.46
Expenditures		
Annual Meeting Expense, 1953		104.40
Postage, Stationery, Supplies		112.15
Printing		148.10
A.A.A.S. Research Grants		195.00
Bank charges		10.80
Bank deposit error		.50
Rubber check		2.50
Secretarial Aid		73.55
Secretarial commission		120.35
Expenses to representative to A.A.A.S. meeting		25.00
High School Committee		65.89
Awards (covered by special gifts)		110.00
Awards to High School students (given by Academy)		40.00
Telephone (long distance)		3.62
Academy Conference		5.00
Reprints of Proceedings		17.55
Elisha Mitchell Scientific Society		544.50
Total		1578.91
Bank Balance, September 1, 1953	105.47	
Plus deposit of Sept. 2	10.00	
	115.47	
Less outstanding checks	29.92	
Adjusted balance	85.55	85.55
		1664.46

Savings Account

Balance (from September 22, 1952)	105.08
Interest	1.04
	106.12

Total Assets

Checking account (adjusted balance)	85.55
Savings account	106.12
U. S. Savings Bonds (maturity value)	300.00
Total	491.67

On the tenth day of September, 1953, we, the undersigned, examined this account and found it to be correct.

(Signed) KEY L. BARKLEY
W. A. REID
B. B. BRANDT, *Chairman*

THE POTEAT AWARD

The award for this year was given to the best paper presented before the Botany Section. The selection was made by members attending the three section meetings of this group where papers were presented. The winner for this year is Miss E. K. Goldie-Smith of the University of North Carolina for her paper, "Members of the Plasmodiophoraceae occurring as parasites of fungi."

REPORT OF THE CONSERVATION COMMITTEE

A serious threat to one of our largest parks was revealed when plans to take over a portion of Crabtree Creek State Park were reported in a newspaper story on October 14, 1952.

In 1951, military authorities surveyed possible sites in Virginia, North Carolina, and South Carolina, which would complement the facilities of Pope Field at Fort Bragg. Results of this survey indicated the desirability of locating the field in North Carolina. Seymour-Johnson Field at Goldsboro and the Raleigh-Durham Airport were the two major sites promoted by the local organizations and members of Congress. The Goldsboro site was tentatively selected, but a controversy immediately developed within North Carolina's congressional delegation caused by complaints from the supporters of the Raleigh-Durham site. Due to this disagreement, no further action was taken until 1952 when a "compromise", whereby North Carolina was to get a base at both fields instead of one as originally planned, was reached. The two-field proposal was approved by the 82nd Congress.

According to the newspaper release mentioned above, when the State Superintendent of Parks, Tom Morse, in order to evaluate the effect such a base would have on the adjoining park, endeavored to secure information from the Army Engineers, he was told by these authorities that such information was classified

and that the expansion plans could not be divulged "at present." Upon reading this report, your committee felt the possibility that our park might be endangered by this development. With this possibility in mind, the committee attempted to assemble all pertinent facts in order to determine what position, if any, it should take in this matter.

Interviews with several members of the Board of Conservation and Development with the hope of obtaining this information, although enjoyable, were conspicuously devoid of the desired details. Since there appeared to be a lack of enthusiasm on the part of some board members to discuss the matter with your representative, it was decided to seek assistance from Congressman Harold D. Cooley, who was able to bring the progress of the surveys and plans up-to-date. Shortly after our inquiry to Mr. Cooley, the Division of State Parks received a copy of the proposed expansion plans from the Army Engineers.

Our suspicions were completely justified when it was ascertained that even the "revised" plans of the Army Engineers involved the taking of "only 238.5 acres" of the park for the construction of a runway extension. The proposed paved extension would not extend further than the relocated boundary; but, in addition, a fan-shaped glide area would continue further into the park for a minimum of 2500 feet and would entail a complete or partial removal of trees within this area. From a center line extension of the runway, a distance of only 1600 feet at right angles remains from the main group camping area, and only 600 feet from the edge of the cleared glide angle area. In actuality, this means that a major strip through almost the center of the park would be kept cleared, making the group camping area a potential death trap as well as destroying the beauty and use of this portion of the area. Since the use of the facilities by jets is contemplated, the noise factor alone would seriously impair the value of the group camping area. This area is customarily used by youth groups and adults from all parts of the State, particularly from Greensboro, Rocky Mount, Greenville, Durham, Burlington, and Raleigh.

It is obvious that the establishment of a military base at the Raleigh-Durham Airport would materially damage, if not destroy completely, the value of one of the most needed and utilized parks in the Piedmont of North Carolina.

Crabtree Creek State Park was established by the Federal Government in 1935 and was transferred to the State of North Carolina by quit-claim deed in 1943. This 3886-acre park is becoming more valuable each day as a recreational and study area. During the last fiscal year, a total of 67,212 persons made active use of its facilities. The passage of each year witnesses a diminution of our natural recreational areas; moreover, in North Carolina's Piedmont today, there is no other unexploited, unposted area of comparable size and location to provide the public with the pleasure and benefit of outdoor recreation and study.

If we are to maintain the integrity of our parks, eternal vigilance and concerted action by every organization interested in their preservation and perpetuation in this state will be required. The total area of all North Carolina State Parks amounts to only ten one-hundredths per cent of the State's total area.

We do not believe that the establishment of a carrier base at the Raleigh-Durham Airport can be justified as being essential to our national defense, since there are certainly a number of equally good alternate locations available that will neither destroy nor damage a State Park.

We wish to recommend to the North Carolina Academy of Science that it go on record by resolution as being opposed both to the location of the carrier air base as now planned at the Raleigh-Durham Airport and to any activity, public or private, which will impair our State and National Parks except in the case of a dire national emergency.

F. S. BARKALOW, JR.
A. F. CHESTNUT
W. A. CHIPMAN
R. J. PRESTON
H. R. TOTTEN, *Chairman*

A Resolution on State and National Parks by the North Carolina Academy of Science, 1953

WHEREAS, Crabtree Creek State Park is one of North Carolina's most important and most needed State Parks; the maintenance of the integrity of all our State Parks free from encroachment and exploitation is essential if they are to be operated in the best public interest; Crabtree Park provides outstanding recreational and instructional facilities for youth groups and citizens throughout the State; the proposed establishment of a carrier base at the Raleigh-Durham Airport will result in the impairment or destruction of the major values of Crabtree Park, as well as rendering the park hazardous for use by the public for a considerable portion of its acreage; the total area of all North Carolina State Parks amounts to only ten one-hundredths per cent of the total state area; and alternate sites are available elsewhere for the establishment of this air base;

NOW THEREFORE, BE IT RESOLVED that the North Carolina Academy of Science be firmly opposed to the proposed establishment of a carrier air base at the Raleigh-Durham Airport which would interfere in any way with Crabtree Creek State Park; that the Academy reassert its opposition to the impairment or destruction of any State or National Park by public or private interests except in the case of dire national emergency; and that the President of the Academy is directed to send a copy of this resolution and a copy of the Report of the Conservation Committee to the Governor of North Carolina, to each of North Carolina's Senators and Representatives, to the members of the Armed Service Committees, and to the Appropriations Committees in the United States Congress, to the Chambers of Commerce of Raleigh, Durham, and all cities from which youth groups attend Crabtree Park, to those organizations concerned with the preservation of the natural beauty and outdoor recreational facilities of this state, and to the newspapers.

The North Carolina Academy of Science unanimously approved this resolution at its annual business session on May 8, 1953.

REPORT OF THE LEGISLATIVE COMMITTEE

In accordance with the instructions contained in the Proceedings of the Forty-ninth Annual Meeting of the North Carolina Academy of Science, Resolution No. 3, the opposition of the Academy to any attempts to legalize the sale of the Venus' Flytrap was called to the attention of the Committees on Conservation and Development and Wildlife Resources of both the North Carolina House of Representatives and Senate. The Senator and the Representatives from Wake County were requested to be alert for any attempts to repeal this protective legislation. No serious effort materialized to authorize the sale of this plant during the current assembly.

In accordance with Resolution No. 5 relating to the introduction and release of exotic animals in North Carolina, several conferences were held with members of the North Carolina Department of Agriculture and State Board of Health. Although your committee devoted a considerable amount of time to this problem, it was unable to prepare a sufficiently comprehensive bill in time to assure its consideration during the current legislative session. Continued efforts in this direction are recommended in order that such legislation be prepared for submission at the next General Assembly.

Your Committee Chairman expressed support of H.R. 1972, a bill introduced by U. S. Congressman Howard H. Baker of Tennessee and designed to set aside ten per cent of revenues from timber sales and other National Forest receipts for development of public-use facilities and to improve wildlife habitat within the forests.

Support of H.R. 4268, by Representative Clifford R. Hope of Kansas, was expressed by the committee. This bill recognizes the multiple-use values of National Forests for watershed protection, timber production, public recreation, grazing, wildlife management, and many other uses. The bill, furthermore, does not favor any single group of uses of the public lands and would assure equal opportunity for use of National Forests by all persons.

Opposition was expressed to the "Stockmen's Bill", H.R. 4023 and S. 1491. Section 5 of the House version places National Forest grazing privileges under local advisory boards similar to those now supervising the administration of Taylor Grazing Act lands. These local boards are notoriously controlled by the livestock interests. Sections 6 and 7 give holders of established grazing privileges "first preference for continued use" and entitle them "to transfer their grazing privileges, as they stand at the time, to successors." These provisions are the *vested rights* in National Forest grazing lands which have been long sought by stockmen and which represent a basic part of the real purposes of this bill. Administrative decisions by the Forest Service or Bureau of Land Management would be made subject to court review, and would, therefore, weaken Federal authority to manage and protect the timber and watershed values in the Forests. Section 11 of the proposed bill states that "nothing herein . . . shall restrict the power of the Secretary (of Agriculture) to limit or discontinue the grazing use of any lands under his jurisdiction for the purpose of preventing injury to said lands from grazing. . . ." This sound and desirable aim is hampered by other

provisions of the bill which raise doubts that the Secretary of Agriculture (Forest Service) would be able to exercise effectively what appears to be clear-cut authority to prevent over-grazing.

Your committee went on record as favoring two bills introduced by Congressman Leroy Johnson, H.R. 1037 and H.R. 1038. The first would establish the Green River Canyons National Park from a portion of the Dinosaur National Monument in Utah and Colorado; the second would prohibit the construction, operation, or maintenance of any project for the storage or delivery of water within or affecting any National Park or Monument.

Considerable work was done by the committee in connection with the proposed air base at the Raleigh-Durham Airport which would involve the taking of considerable acreage of Crabtree Creek State Park. A detailed report of these activities is incorporated into the Report of the Conservation Committee.

C. G. BOOKHOUT
B. W. WELLS
F. S. BARKALOW, JR., *Chairman*

REPORT OF THE COMMITTEE FOR HIGH SCHOOL SCIENCE

The first meeting of the committee was held October 4, 1952 with all members of the committee present. The discussion covered the following:

1. The High School exhibit and essay regulations to be amended as follows:

   Exhibits.—One student, or a group of two or three students, may enter an exhibit to compete for the cash prizes offered. A group of more than three students, a science class, or a science club may enter an exhibit in any of the classes listed to compete for certificates of award.

   Exhibits shall remain on display until two o'clock Saturday afternoon, May 9.

   Exhibits shall be judged by members of the Academy.

   Essays.—Not more than four essays on each title may be entered from the same high school.
2. That a list of all high school science teachers in North Carolina be obtained from Mr. Henry A. Shannon, Advisor, Science and Mathematics, Department of Public Instruction, and that the information concerning the essays and exhibits be mailed to these teachers.
3. That the publicity for the High School Science of the Academy be improved.
4. That arrangements be made for a special meeting of the High School Science teachers at the annual meeting of the Academy. The subject preferred for this meeting was atomic energy.

The second meeting of the committee was held March 7, 1953 with all members present except Mrs. Copeland. The following reports were made:

1. On January 5, 1953 a four-page mimeographed announcement describing the classes of exhibits, titles for essays, prizes, and regulations was sent to the high school science teachers and high school supervisors in North Carolina.
2. That arrangements had been made for a High School Science Teacher luncheon to be held at 12:30 on Saturday, May 9.

3. That Dr. C. K. Beck (Head of the Physics Dept., N. C. State) had agreed to conduct a tour of the Nuclear Reactor for the High School Science Teachers on Saturday afternoon at 2 o'clock, May 9.
4. That an article submitted by Miss Freeman and Mr. Smith appeared in the Journal of the N. C. E. A., concerning the essays and exhibits sponsored by the Academy.

Work of the Committee since March 7:

1. A News Letter was sent to all high school science teachers and high school supervisors in North Carolina.
2. A total of 26 essays were received, 14 in ornithology and 12 in forestry, representing 13 high schools.
3. Exhibits were listed with the chairman of the Committee by April 15. 32 entries were received, representing 14 high schools.
4. The committee wishes to thank Miss Mary O. Ellington and her group for their arrangement of the exhibits.

B. B. BRANDT
MRS. ERIC COPELAND
CLAIRE FREEMAN
GARMON B. SMITH
CHRISTINE WILTON
MARY E. YARBROUGH, *Chairman*

HIGH SCHOOL CONTESTS WINNERS

Forestry Essay Contest

(*Sponsored by the North Carolina Forestry Association*)

"Modern Methods of Forest Conservation in North Carolina"

First Prize: James C. Carroll, Mount Olive High School, Mount Olive
Second Prize: Mary S. Wolfe, Mount Olive High School, Mount Olive
Third Prize: Becky Geddie, Lumberton High School, Lumberton

Ornithology Essay Contest

"Birds of Value to the Farmer"

First Prize: Susan McIntyre, Lumberton High School, Lumberton
Second Prize: Betty Willoughby, Lumberton High School, Lumberton
Third Prize: Nay Ann Rogers, Edneyville Schools, Edneyville

Exhibits Contests

Group I. Living Plants or Animals (*Sponsored by Carolina Biological Supply Co.*)
First Prize: Mike Marshall and Billy Everhart, Grey High School, Winston-Salem
"Tropical Fish"

Group II. Preserved Plants or Animals (*Sponsored by Carolina Biological Supply Co.*)

First Prize: Morris H. Vaughn, New Hanover High School, Wilmington
"Marine Life"

Group III. Models

First Prize: Dwayne Lowder, Albemarle High School, Albemarle
"Fire Hazards"

Group IV. Original Projects.

First Prize: Charles Canady, Guilford High School, Guilford
"Time Switch"

Group V. Chemistry Exhibits (*Sponsored by Cardinal Products, Inc.*)

First Prize: Jim Bynum and Dick Chalke, Greensboro Senior High School, Greensboro
"Atom Models"

Second Prize: James MacIntosh and Homer Gilbert, North Mecklenburg Senior High School, Charlotte

REPORT ON THE ACADEMY CONFERENCE AND THE A.A.A.S. COUNCIL

Your Secretary was appointed as your representative to the Academy Conference meeting at St. Louis in December of 1952 and as your representative on the A.A.A.S. Council meeting at the same convention.

The Academy Conference.—A business meeting of the Academy Conference was held on the morning of Dec. 28, 1952 in the Hotel Jefferson, St. Louis, Mo. Representatives of 29 and the 38 academies which are currently affiliated with the Conference and active were present, a record in attendance. In addition to the routine of approving minutes and making minor changes in the constitution and rules of order, the following committees presented reports: Committee to Study Opportunities for Cooperation Between Academies, Committee to Study Cooperation of the Academies of Science with the Academy Conference, Committee to Sponsor the Junior Scientists' Assembly, and Resolutions Committee. A major emphasis in more than one of these reports was to the effect that Academies would profit through interchange of programs and visits from scientists from adjoining states, and in all more information on the activities of neighboring State Academies. A carefully prepared history of the activities of the Academy Conference has been prepared by Dr. Clinton L. Baker of Southwestern University and was presented in mimeographed form to all present. The newly elected officers of the Academy conference are Dr. Percival Robertson, The Principia College, president, and Mr. Wayne Taylor, Denton High School, Denton, Texas, president-elect. Dr. Leland H. Taylor of West Virginia University is to continue as secretary.

During the afternoon of the same day, round table discussions on several topics were scheduled, including the following: Responsibilities of Academies of Science in Promoting Improvement in the Teaching of Science in the Public Schools, by Miss Greta Oppe, Galveston, Texas; The Relation of Academies of Science to College Students, by Dr. Harold R. Wanless, University of Illinois; The Relation of Academies of Science to the Public, by Dr. Harold E. Wilcox, Birmingham-Southern College; and The Relation of Academies of Science to the Press by Mr. Watson Davis, Director of Science Service, Washington, D. C. As

indicated by these titles the emphasis was on the service which Academies may render to the immature scientists in high school and undergraduate levels, the need for the presentation of science, and its significant contributions to the general public. The use of media such as radio and TV was stressed by some persons who have successfully used these.

The A.A.A.S. Council—The Council held two meetings during the St. Louis gathering, at 4 p.m. on December 27 and at 9:00 a.m. on December 30 in the Hotel Jefferson. 106 members were present. Dr. Warren Weaver was selected as president-elect, while Dr. Mark H. Ingraham, Dr. Paul E. Klopsteg, and Dr. Wallace R. Brode were elected as members of the Executive Committee. A thoroughly revised constitution was presented by Dr. Kirtley F. Mather and was adopted by the Council. The construction of a building on the property on Massachusetts Avenue, Washington, owned by the Association, has been halted by an adverse ruling of the Zoning Board in Washington. No solution was in evidence. There was some discussion of the effect of the McCarron-Walter Act of 1952 upon the movements of scientists into and out of the United States. An analysis of this Act has been prepared by two persons with the National Science Foundation and is available in mimeographed form if not by this time in published form. Future meetings of the A.A.A.S. will be as follows: 1953, Boston; 1954, on the Berkeley campus of the University of California; 1955, Chicago; 1956, New York. Dr. E. U. Condon took office as president of the Association on January 14, 1953. As an appendage to this report it may be stated that Dr. Howard A. Meyerhoff, Administrative Secretary of the Association and Miss Gladys M. Keener, Executive Editor of its two publications Science and the Scientific Monthly, have resigned as of March 31 last, because of reported serious friction between themselves and the two top officers, Dr. Condon, president and Dr. Weaver, president-elect.

JOHN A. YARBROUGH

REPORT OF THE JOHN BEWLEY DERIEUX MEMORIAL AWARD COMMITTEE

One paper was submitted this year which received the unanimous approval of members of the committee to receive the award. The paper, "Qualitative Aspects of Cosmic Ray Particles", was submitted by Charles B. Childs of the University of North Carolina. Mr. Childs was presented the award and certificate at the evening session of the Academy on May 8 by the chairman of the committee.

W. E. SPEAS
H. D. CROCKFORD
E. G. PURDOM, *Chairman*

REPORT OF THE RESOLUTIONS COMMITTEE

Be it resolved that the North Carolina Academy of Science express to Chancellor J. W. Harrelson, the other administrative officers, the faculty, and the students of the North Carolina State College of The University of North Carolina its gratitude for the hospitality and many services that contributed to the success of the Academy's fiftieth meeting. Be it further resolved that the Academy

convey its great appreciation to the members of the local Committee on Arrangements for their role in planning for this meeting.

Be it further resolved that a copy of this resolution be incorporated into the minutes of the Academy and that copies be sent to Chancellor Harrelson and to the Chairman of the Committee on Arrangements.

DOROTHY C. ADKINS

The above resolution was unanimously approved by the Academy.

Memorials to the following members were read before the Academy: James L. Lake, Charles McGee Heck, William Basil Fox. Each memorial was approved by a rising vote.

JAMES L. LAKE

James L. Lake, professor emeritus of physics at Wake Forest College, died September first, 1952, at his home in Wake Forest at the age of 91. He was born at Waverly, Surry County, Virginia, October the fifth, 1861. When he was eleven years of age, his father, a distinguished Baptist minister, became pastor of the Baptist Church at Upperville, Virginia, where he established a home and served as pastor of the church for fifty years. Professor Lake and his family spent summer vacations at the home in Upperville as long as his father lived. Although he spent the major portion of his life at his Wake Forest home, the old home in Upperville was foremost in his mind. He was an ardent Virginian, and his mortal remains rest in the family plot at Upperville.

He attended Richmond College, now Richmond University, and won the master of arts degree in 1882. He was a graduate student in mathematics and physics at Johns Hopkins University for three years, 1890–93. He held a fellowship in physics for two years at the University of Chicago, where he studied under the direction of the renowned physicist, Albert A. Michelson. He was professor of natural science at Bethel College, Kentucky, 1893–96; professor of mathematics and physics at Ursinus College, Pennsylvania, 1898–99; professor of physics at Wake Forest Collegee, 1899–1932; professor emeritus, 1932–52.

He was for many years a faithful and loyal member of the Academy. He served as president of the Academy during the academic year 1921–22.

His former students will remember him as an able, thorough, and enthusiastic teacher of physics. They will recall his fairness and honesty, and his skill in the application of mathematics to physics problems. But the characteristic which they will remember the longest and most vividly was his gentlemanly manner in dealing with them. He was a superb gentleman. He will be remembered by his faculty associates, and by the people of Wake Forest for his generous spirit of hospitality. He enjoyed life in the fullest measure. One of the contributing factors in his enjoyment of life was his splendid family. He is survived by his wife, the former Virginia Caldwell of Kentucky, and three sons and two daughters. He had a keen sense of humor. On one occasion he gave a boy the grade zero on an examination paper. The boy protested, saying that he didn't think he deserved the grade. Professor Lake's reply was that he knew he didn't but according to the rules of grading, zero was the lowest grade he could give him.

Wake Forest and the State of North Carolina have lost a noble citizen, and the Academy a loyal member.

W. E. SPEAS

CHARLES MCGEE HECK

Charles McGee Heck, Professor Emeritus of Physics at North Carolina State College, died at Rex Hospital in Raleigh on November 23, 1952 following an illness of several months. He is survived by his wife, the former Maude Williams, and one son, Charles.

Professor Heck was born at Raleigh, May 28, 1881, and attended the public schools and the Morson and Denson High School of that city. He attended Wake Forest College from which he received the B.A. degree in 1900. In 1901 he was awarded the M.A. degree from Columbia University. In 1902–1903 he was a Fellow in Physics at the University of Nebraska and from 1903 until 1905 he was a student at the University of Berlin. In 1905 he accepted a position as Instructor in Physics at the University of Nebraska and served in that institution successively as Adjunct Professor and Assistant Professor until 1911. During the 1912–1913 session he was Associate Professor at Colorado College. In 1913 he came to North Carolina State College as Associate Professor and in 1917 was made Professor and Head of the Physics Department at that institution in which capacity he served until his retirement in May 1946.

Professor Heck was a member of the American Physical Society, the American Association for the Advancement of Science, the Southeastern Section of the American Physical Society, and the North Carolina Academy of Science. Of these, he felt closest to, and enjoyed most, our Academy of Science. He served the Academy as its President in 1924, and served on the Executive Committee during the years 1924–1926 and again during 1932–1934. He was always interested in the purpose and growth of the Academy and gave freely of his time and talents to assist in its development. As an illustration of his interest in promoting science, he gave illustrated lectures and conducted a survey of science teaching in the high schools of thirty North Carolina counties during the years 1924–1926.

Professor Heck was interested in a variety of activities and possessed a fertile imagination. He was an interesting lecturer with a keen sense of humor and enjoyed his associations with students and fellow workers. To his staff members he gave freedom and encouragement for the development of their individualities as teachers. He had issued to him a number of patents in the fields of sound and heat. He had a strong interest in research, which included work on electrophoresis in liquid dielectrics, relation of atmospheric pressure to radio reception, physical properties of oil films on water, spiral formations in paraffin crystals, and thermal radiation from the upper atmosphere. He had a strong interest in local history and spent a considerable amount of his time after retirement in research dealing with the early history of Raleigh.

During his long period of service in North Carolina, Professor Heck won the deep respect and admiration of his associates and students through his friendly personality, broad interests, and human understanding. We wish hereby to

express our deep feeling of loss in the passing of this able co-worker, scientist, and friend.

J. S. MEARES

WILLIAM BASIL FOX

It is with sorrowful regret that we record the untimely death of William Basil Fox at Raleigh, North Carolina, on November 13, 1952. For six years he had been a member of the Botany Faculty of the North Carolina State College where he taught dendrology and plant taxonomy, and where he was actively engaged in research on the flora of North Carolina. During this time, also, he was a faithful member of the North Carolina Academy of Science, the Botanical Section of which he served as secretary from 1950 until his death.

Dr. Fox was born at Talcott, West Virginia, on July 20, 1915. He graduated from the Talcott High School in 1932. His college and university training encompassed three years study (1932–35) at the Concord State Teachers College; three years (1937–40) at the West Virginia University from which he obtained the Bachelor of Science and the Master of Science degrees; and two years (1940–42) at the State University of Iowa, which conferred upon him the degree of Doctor of Philosophy.

From 1942 to 1945, Dr. Fox served as Technical Instructor with the War Department. The year following he held a position as Assistant Agronomist at the Washington State College from whence he came to the North Carolina State College in the autumn of 1946 as Assistant Professor of Botany. He had been on leave-of-absence from March through August, 1952, during which time he served with the Division of Plant Exploration and Introduction of the United States Department of Agriculture as a plant explorer in Mexico.

It is very largely owing to Dr. Fox's initiative and enterprise that the North Carolina State College may now boast the nucleus of a fine regional herbarium. He was its first curator. The writer, and other members of this Academy, may recall with much pleasure our experiences in the field with him during the past several years. His enthusiasm and his painstaking methods as regards research on the flora of the State and the development of the herbarium were such as to inspire others of us henceforward to further those projects.

As a classroom teacher, Dr. Fox was outstandingly successful. In addition, his advocacy and influence stimulated a number of worthy students to pursue advanced studies. Not the least among his fine qualities was a quiet wit which was enjoyed by students and colleagues alike. While we send our sympathy to Mrs. Fox, and to his son, Stephen, we express to them, too, our sincere appreciation of the fact that we were privileged to know him and to work with him.

ROBERT K. GODFREY

REPORT OF THE NOMINATING COMMITTEE

The committee, consisting of W. C. George, chairman, H. L. Blomquist and Z. P. Metcalf, submitted the following nominations:

President: Donald B. Anderson, N. C. State College.

Vice-President: Florence Schaeffer, Woman's College of U. N. C.
Member of the Executive Committee: E. W. Berry, Duke University
Member of Research Grants Committee: O. J. Thies, Davidson College (3 years)

The above nominees were unanimously elected by the Academy. This concluded the business and the meeting was adjourned.

Approximately 150 members of the Academy and their wives enjoyed the Golden Anniversary Dinner of the Academy which was held in Leazer Hall on the N. C. State Campus at 6:15 p.m. Members and guests were welcomed by Chancellor J. W. Harrelson of N. C. State College. Mr. S. W. Hoffman was recognised at this meeting as a new Life Member of the Academy. President Stuhlman presided over a brief program at the dinner consisting of reminiscenses out of the past fifty years by certain former presidents of the Academy. At 7:45 the evening session was held in the auditorium of Williams Hall with Vice-President Harkema presiding. The 1952 Poteat Award was presented to Dr. Marjorie Swanson of Bowman Gray School of Medicine and the 1953 John Bewley Derieux Memorial Award to Charles B. Childs of the University of North Carolina. Dr. Mary E. Yarbrough announced the winners of the High School Essay Contests. The interesting address of President Otto Stuhlman was enjoyed by the membership and guests.

The following officers were elected for the respective sections:
Biochemistry and Physiology: Chairman, Marjorie A. Swanson; Secretary, G. H. Satterfield
Botany: Chairman, Thomas E. Smith; Secretary, Ben W. Smith
Geology: Chairman, Warren Steel; Secretary, E. W. Berry
Mathematics: Chairman, E. L. Mackey; Secretary, P. C. Scott
Psychology: Chairman, D. J. Moffie; Secretary, Marion Stanland
Wildlife: Chairman, Thomas L. Quay; Secretary, Fred A. Barkalow
Zoology: Chairman, T. H. Eaton; Secretary, C. E. Jenner

The following constitute the personnel of the standing committees:
Executive: Donald B. Anderson, Florence Schaffer, John A. Yarbrough, W. O. Puckett, Eva G. Campbell, E. W. Berry
Research Grants: W. O. Puckett, L. E. Anderson, H. E. LeGrand, O. J. Thies

Dr. Donald B. Anderson, President of the Academy for 1954, announced the appointment of the following committees:
Auditing: B. B. Brandt, chairman; W. A. Reid, Key L. Barkley
Nominating: C. F. Korstian, chairman; H. R. Totten, P. M. Ginnings
High School Exhibits: Mary O. Ellington, chairman; Mary E. Yarbrough, Hollis J. Rogers, Henry A. Shannon, Mazel B. Lyke
Conservation-Legislative: F. S. Barkalow, chairman; A. F. Chestnut, T. E. Maki, Wanda Hunter, Coy T. Phillips, Laura Owens
Resolutions: Eva R. Balken
Derieux Memorial Award: Guita Marble, chairman; R. M. Helms, F. W. Lancaster
Representative on A.A.A.S. Council: John A. Yarbrough
Representative to Academy Conference: John A. Yarbrough

The following papers were presented during the meetings. Those marked with an x are abstracted in these proceedings:

Presidential Address: Some Scientific Facts and Fallacies. Otto Stuhlman, University of North Carolina

SYMPOSIUM ON THE USE OF ISOTOPES IN BIOLOGICAL AND MEDICAL RESEARCH

Radio-isotope preparations. A. F. Rupp, Oak Ridge National Laboratory

Carbon-14 and other isotopes in plant biochemistry. N. Edward Tolbert, Oak Ridge National Laboratory

Isotopes in medical research. Philip Handler, Duke School of Medicine

The use of isotopes in marine biology. Walter A. Chipman, Shellfish Laboratory, Beaufort

SYMPOSIUM ON TEACHING THE COLLEGE BIOLOGY COURSE

The one term course in the fundamentals of biology at N. C. State College. John L. Evers, N. C. State College

General biology at East Carolina College. Christine Wilton, East Carolina College

The general biology program at Woman's College, U. N. C. Victor M. Cutter, Jr. and Charlotte Dawley, Woman's College, U. N. C.

The natural science program at the University of North Carolina. J. E. Adams, U. N. C.

General biology at Wake Forest College. E. C. Cocke, Wake Forest College

BIOCHEMISTRY-PHYSIOLOGY SECTION

Chemical and electrical activity of perfused cat heart under various conditions. J. R. C. Brown and P. A. Khairalla, Duke

Acetal phosphatide and blood clotting. C. L. Yarbro, J. H. Ferguson and C. E. Anderson, U. N. C.

The hematocrit and hemoglobin response in blood donors. B. T. Cole, K. E. Penrod and F. G. Hall, Duke

Carbon dioxide and respiratory regulation at altitude. F. G. Hall, Duke

Role of choline in fatty acid oxidation in liver tissue. C. Artom, Bowman Gray

Trimethylamine production from choline in liver tissue. C. Artom, M. Crowder and H. B. Lofland, Bowman Gray

A proposed treatment for osteomyelitis. William Russell, Salem College

Some properties of the mitochondrial ATPase. M. A. Swanson, Bowman Gray

Characteristics of certain voluntary muscles in dogs. Maude Williams, Woman's College, U. N. C.

BOTANY SECTION

x*Sooty mold on peanuts.* W. E. Cooper, N. C. State

The occurrence of thin-walled sporangia in Physoderma Zeae-maydis on corn in the field. J. N. Couch, U. N. C. (Printed in full in the current issue of the Journal.)

x*Members of the Plasmodiophoraceae occurring as parasites of fungi.* E. K. Goldie-Smith, U. N. C.

x*Aerobiology in national defense.* Morris A. Gordon, U. S. Public Health Service, Chamblee, Georgia

x*Systemic infection of soybean by Peronospora manshurica as affected by temperature.* S. G. Lehman, N. C. State

An interpretation: sexuality of fungi. F. A. Wolf, Duke

x*Inheritance of a bitter principle in cucumbers.* W. S. Barham, N. C. State

x*Inheritance of an undesirable flavor in tomatoes.* E. A. Borchers and W. S. Barham, N. C. State

x*On the influence of temperature on a genetic ratio.* D. U. Gerstel, N. C. State

x*Arachis hypogaea. Behavior of the induced mutant "Cup".* Ray O. Hammons, N. C. State

x*Several considerations regarding chromosomes and evolution in the Angiosperms.* Henry W. Jensen, Warren Wilson College

x*Embryo and seed failure following hybridization of Arachis hypogaea and A. diogoi.* Eloise L. Johansen, N. C. State

x*Heredity and nutrition in relation to magnesium deficiency chlorosis in celery.* D. T. Pope, N. C. State.

Arachis hypogaea: Reproductive efficiency. Ben W. Smith, N. C. State

x*The breeding system in cotton and its possible significance in methods of cotton improvement.* S. G. Stephens, N. C. State

Vascular system of shoots of Tropaeolum majus after treatment of the shoot apex with indoleacetic acid. Ernest Ball, N. C. State

The genus Xyris in North Carolina. H. L. Blomquist, Duke

Chloride induced hypertrophy of dune plants. Steve G. Boyce, N. C. State

Notes on the distribution of the genus Scirpus in North Carolina. E. Dan Cappel, N. C. State

x*Plant exploration in the Union of South Africa.* R. K. Godfrey, Division of Plant Exploration and Introduction, Beltsville, Maryland

x*Some cytological and anatomical effects of maleic hydrazide.* Victor A. Greulach and John G. Haesloop, U. N. C.

Embryo culture studies in Solanum tuberosum. F. L. Haynes, N. C. State

x*Translocation of P^{32} injected by Myzus persicae (Sulz.) into tobacco plants.* F. R. Lawson, G. B. Lucas, and N. S. Hall, Tobacco Experiment Station, Oxford, N. C. and N. C. State

x*A new Houstonia from Randolph County, N. C.* Hollis J. Rogers, Woman's College, U. N. C.

The structure of the epidermal wall of the tobacco petiole. Richard J. Volk, N. C. State

Translocation of radio-active isotopes from various regions of barley roots. Herman Wiebe, N. C. State

GEOLOGY SECTION

x*The clay minerals and the iron oxide minerals of the Triassic "Red Beds" of the Durham Basin, N. C.* W. Gary Hooks and Roy L. Ingram, U. N. C.

x*Why the "whiteness" of White Lake (Bladen Co., N. C.)?* B. W. Wells, N. C. State

x*Establishment of a seismological observatory at Chapel Hill.* Gerald R. MacCarthy, U. N. C.

x*Chemical analyses of ground water as an aid to mapping the Tertiary limestone unit in North Carolina.* H. E. LeGrand, U. S. Geological Survey

x*Submarine canyons–where are they off the coast of North Carolina?* Duncan Heron, Duke

x*Chance of observation in geology.* E. C. Van Horn, The Hitchcock Corporation, Murphy, N. C.

x*Clay minerals of the Tuscaloosa formation near Fayetteville, N. C.* Roy L. Ingram, U. N. C.

x*Investigation of limestone in eastern North Carolina.* Jasper L. Stuckey, N. C. State Department of Conservation and Development

x*19th Geological Congress.* E. W. Berry, Duke

x*The clay minerals of Neuse River sediments.* Charles Q. Brown and Roy L. Ingram, U. N. C.

x*Preliminary geology of southwest part of the Raleigh quadrangle.* N. C. John M. Parker, III, N. C. State

MATHEMATICS SECTION

x*The volume of a portion of a cylindrical tank with spherical ends.* Anne Lewis, Woman's College, U. N. C.

The osculating parabolas to any curve. E. F. Canaday, Meredith

A mathematical examination of spiraled compound curves. T. F. Hickerson, U. N. C. (Printed in full in the current issue of the Journal.)

Some observations on undergraduate mathematics in American colleges. E. A. Cameron, U. N. C.

x*An algorithm for the diagonalization of a symmetric matrix.* H. M. Nahikian, N. C. State

x*On the least primitive root of certain primes.* A. T. Brauer, U. N. C.

x*Polarization as applied to the general surface.* A. T. Curlee, Salem College

WILDLIFE SECTION

Migratory tendencies of the Manchester (IA.) strain of rainbow trout. H. M. Ratledge, N. C. Wildlife Resources Commission

Non-seasonal deer mortality. Kenneth Chiavetta, N. C. Wildlife Resources Commission

Woodcock breeding in North Carolina. T. Stuart Critcher, N. C. Wildlife Resources Commission

Reproduction studies of the muskrat near Moyock, N. C. Kenneth A. Wilson, N. C. Wildlife Resources Commission

Food habits of the mourning dove in North Carolina. Edmund G. Cummings, N. C. State

ZOOLOGY SECTION

Damage to fabrics by silver fish and fire brats. Charles H. Brett, N. C. State

x*Egg production and hatchability in the wasp, Habrobracon.* D. S. Grosch, N. C. State

x*Injection experiments with vital dyes; Habrobracon larvae fed on dye-injected hosts.* R. L. Sullivan and D. S. Grosch, N. C. State

Sampling soil insect populations. Walter M. Kulash, N. C. State

Moulting and growth in the barnacle, Balanus improvisus. John Costlow and C. G. Bookhout, Duke

x*The ecological distribution of spiders in non-forest maritime communities at Beaufort, N. C.* Robert D. Barnes, Duke

x*Swimmer's itch in Alaska.* Reinard Harkema, N. C. State

x*Studies on host tissue reaction to chigger bite.* Joshua R. C. Brown and George W. Wharton, Duke

x*The wild bird as a factor in breeding attractive flowers.* A. L. Pickens, Queens College

x*Pygmy sunfishes and the meaning of pygmyism.* T. H. Eaton, Jr., East Carolina College

x*Habitat and territory in Macgillivray's seaside sparrow.* T. L. Quay, N. C. State

Sooty Mold on Peanuts. W. E. COOPER.

Sooty mold was observed on peanut plants for the first time in August, 1952. Although it has probably occurred on peanuts before this no reference to it was found in the literature. The peanuts were growing in close proximity to corn and cotton in rotation study on the Peanut Experiment Station, Lewiston, N. C. Further observation indicated that the disorder was associated with the proximity of corn to the peanuts. This was checked by collecting three series of samples of peanut leaves at various distances from the corn and rating the leaves individually for disease severity. The average disease rating decreased inversely with the square of the distance from the corn on the west side of the peanuts. The proximity of corn on the east had relativity little influence on the amount of disease.

In addition to the "sooty" appearance there was some necrotic flecking. These small dark-brown to black flecks or spots were usually limited to the epidermal layer although some of the larger spots extended down into the palisade cells. Microscopic observation of material from the surface of affected leaves revealed a fungal mat, typical of the sooty mold fungi, and numerous corn pollen grains. Most of the pollen grains were invaded by mycelium of the sooty mold fungus.

The association of the disease with the proximity of corn plants and the accumulation of corn pollen on the peanut leaves indicate that insufficient rainfall to wash the pollen from the leaves was probably a contributing factor in the development of this disease on peanut.

Members of the Plasmodiophoraceae Occurring as Parasites of Fungi. E. K. GOLDIE-SMITH.

The Plasmodiophoraceae are known chiefly as parasites of flowering plants, and the only established members of the group hitherto described on fungi are *Octomyxa Achlyae* Couch, Leitner and Whiffen, *O. Brevilegniae* Pendergrass, both parasitizing the Saprolegniaceae, and *Sorodiscus Cokeri* Goldie-Smith on *Pythium*. In this paper, evidence is presented in support of Dr. J. T. Barrett's observations (unpublished) which show that *Woronina polycystis* Cornu, on

Saprolegniaceae, should also be placed in this group, and a new species of *Woronina* is described as a parasite of *Pythium*. Comparisons are drawn, including extensive tests of host relationships, and the value of the configuration of the cystosorus as a diagnostic feature is emphasized, particularly as it has been found that members of two distinct genera, *Sorodiscus Cokeri* and the new species of *Woronina*, will parasitize the same host, a single strain of *Pythium proliferum*.

Aerobiology in National Defense. MORRIS A. GORDON.

Adequate defense preparation against biological warfare requires the development of efficient methods for detection and rapid identification of possible airborne pathogenic micro-organisms. Most of the air-sampling devices thus far considered for trapping bacteria will handle only small volumes of air, about one cubic foot per minute (c.f.m.). A large model venturi scrubber now being tested readily handles 25 c.f.m. and appears to be relatively efficient at trapping small particles. A commercial air-cleaning apparatus incorporating the venturi principle, with a capacity of 500 c.f.m., has also been tested. Some characteristics of these scrubbers, and comparisons with an efficient low-volume sampler, the Shipe tangential -jet impinger, are presented.

Systemic Infection of Soybean by Peronospora manshurica as Affected by Temperature. S. G. LEHMAN.

Peronospora manshurica, the causal agent of the downy mildew disease of soybean, overwinters by means of oospores adhering to seeds harvested from infected plants. When soybean seeds encrusted with oospores were planted in moist soil in the greenhouse and held for two weeks at mean temperatures of 59°, 69° and 75° F., symptoms of systemic infection occurred subsequently only on plants from the seeds germinated at 59° F. Out of 53 plants from seed held for two weeks at this temperature, 21 plants became infected systemically. None of the plants from seeds held for two weeks at 69° or 75° F. developed any symptoms of systemic infection although allowed to grow till flowering time. Changing these plants to a lower temperature after the second week had no effect on the percentage of plants systemically infected.

In another test with seed of a different variety, 39.2 per cent of the young plants from seed germinated in a cold room held steadily at 55° F. for two weeks developed symptoms of mildew. Also systemic mildew developed on 35.3 per cent of the plants growing from seeds held in a greenhouse at a temperature fluctuating around means of 57° F. and 54° F. during the first and second weeks respectively. None of the plants from seed held to germinate at a non-fluctuating temperature of 65° F. for two weeks in a cold room became infected systemically.

In these tests, macroscopically visible symptoms of systemic infection were associated with slow growth of seedlings conditioned by low temperature during the period of seed germination.

The Inheritance of a Bitter Principle in Cucumbers. WARREN S. BARHAM.

A plant introduction cucumber (P. E. I. 173889) found to be resistant to downy and powdery mildew by Dr. F. T. McLean of the Virginia Truck Experiment

Station produces very bitter tasting fruit. Test by Dr. I. D. Jones of the Horticulture Department at North Carolina State College showed conclusively that the usual brining and processing procedures do not remove or mask the bitter taste.

In studying the inheritance of the bitter principle character it was found that the character for bitterness is controlled by a single dominant gene. Although the inheritance of the resistance to downy mildew carried by P. E. I. 173889 has not been determined, it has been found that resistance to downy mildew is either not linked or not very closely linked with the bitter character.

The Inheritance of an Undesirable Flavor in Tomatoes. E. A. BORCHERS AND W. S. BARHAM.

The fruit of a tomato line obtained from Puerto Rico used in a southern bacterial wilt breeding program has a very undesirable flavor. Plants possessing this flavor have been found among the progenies of the Puerto Rico line crossed with commercial tomato varieties.

Two commerical varieties, F_1, F_2, and backcrosses between these commerical varieties and the Puerto Rico line were used in studying the inheritance of the undesirable flavor.

Classification of populations on the basis of undesirable flavor was accomplished by adding Mayer's reagent to the filtered juice of fruit from individual plants. The amount of flavor compound present was indicated by the precipitate formed and was measured in a spectrophotometer.

On the Influence of Temperature on a Genetic Ratio. D. U. GERSTEL.

Hybridization between different species frequently yields combinations which are non-viable; several such cases are known among the cottons of which the newest one is described here together with some of its particular features. In a cross between a tetraploid of the *sanguineum* strain of the Asiatic cotton *Gossypium arboreum* and Upland (*G. hirsutum*) the leaves of all hybrids became discolored and dropped, leading to death before the flowering stage. In a multiple interspecific cross 4n (*sanguineum* × *G. herbaceum*) × Upland 171 out of 207 plants died at various stages of development, which indicated a tetrasomic 5:1 ratio for the lethal factor symbolized as Rl_a (red lethal complementary). Intensity of abnormal symptoms and time of death could be modified genetically—e.g. by using different Upland strains—or by temperature. In a preliminary experiment with different temperatures only two out of nine plants showed any abnormal symptoms in a cool greenhouse (at a constant 70°F) while in a warm greenhouse (day temperatures 80–100°F) all but one out of nine plants died with the symptoms. These differences suggest that dominance had been reversed.

Arachis hypogaea. Behavior of the Induced Mutant, Cup. RAY O. HAMMONS

The mutant *cup* was one of a number of mutations induced by treating dormant peanut seeds with X-rays. Treatment consisted of 18,500 $r \pm 15\%$. Based on analysis of 1770 progenies in the second generation (X_2), *cup* frequency was

estimated at 3 per cent. *Cup* plants were characterized by a complex of morphological features ascribed to pleiotropy. Diagnostic features were involute leaflets disposed in the form of a cup and succulent, easily broken stems.

Inheritance of *cup* as a simple mendelian recessive was affirmed in naturally self- and artificially cross-pollinated progenies. Homozygotes reproduced the mutant type and heterozygotes segregated 3:1 phenotypic and 1:2:1 genotypic ratios. The backcross ratio was 1:1.

Mutant phenotypes were expressed with recognizable grades of intensity attributed to interaction of the changed "gene" and the modifying effects of the altered genotype in which it was expressed. Strong evidence for this association was suggested by a highly significant regression of ranked grade expression on yield of fruits.

The genetic symbol *cu* is proposed for the *cup* allele, with *Cu* representing normal.

(This work was supported by the U. S. Atomic Energy Commission under Contract No. AT-(40-1)-265, and was conducted at North Carolina State College. The seeds were irradiated at the Oak Ridge National Laboratory).

Several Considerations Regarding Chromosomes and Evolution in the Angiosperms. HENRY W. JENSEN.

Cytological investigations of the native Angiosperms of western North Carolina suggest two generalizations: 1, Angiosperms, exclusive of polyploid genera, usually exhibit to a varying degree vagaries of what is considered the "normal" meiotic process, whereas perfectly regular meiosis is only typical of polyploid species; 2, because low chromosome numbers occur in both Orchids and Composites, as well as in the primitive families of Angiosperms, the major evolutionary line has been confined to plants of low chromosome number. Using the above generalizations, the hypothesis is advanced that if one assumes that somewhere in the Angiosperm complex are one or more latent groups capable of establishing a new major evolutionary line, it might be possible to discover such species or group of species by looking for a plant with a low number (4–9 haploid), with a meiosis in which some of the chromosomes obviously behave irregularly, especially a species in which one or more chromosomes may be left out of the complement without affecting the phenotype of the species. Meiosis in *Claytonia virginica* suggests this type, wherein the normal haploid number is 12, but plants of 10–14 haploid were suspected, both from counts and the irregular behavior of one and sometimes two chromosomes during microsporogenesis. Apparently the loss of one or two chromosomes, ergo up to 16% of its normal chromatin constitution, does not affect the genetic expression in this instance. Extending this line of reasoning would suggest that *major* evolution will occur only in organisms whose chromosomes are *unspecialized*—that is, chromosomes onto which genetic factors have not become fixed, in contrast to the closed-end type of evolution so well studied amongst polyploids and introgressive complexes. Or, conversely, once chromosomes acquire a static genetic value, their usefulness in the major evolutionary chain is over. The old assumption that major evolution followed the

mechanics considered effective for minor variations no longer seems tenable, and a new approach to the problem is submitted as a more profitable avenue of research for those who are interested in establishing something more than an improved variety of peanuts.

Embryo and Seed Failure following Hybridization of Arachis hypogaea *and* A. diogoi. ELOISE L. JOHANSEN.

Attempts to hydridize the cultivated peanut, *Arachis hypogaea* L., with the wild related species have not been successful. Following the cross *A. hypogaea* ($n = 20$) $\times$ *A. diogoi* ($n = 10$) fruit enlargement sometimes occurs but no seeds develop.

Examination of ovules from cross-pollinated flowers showed that fertilization did occur following this cross. Hybrid embryos and endosperms developed for a time, but at a markedly slower rate than in *A. hypogaea*. The integuments, diploid maternal tissues, grew rapidly and became abnormally thickened, eventually causing the complete collapse of the embryo sac. The hybrid endosperm was destroyed by this collapse, but the hybrid embryo survived for a longer time. The final destruction of the embryo appeared to result from starvation and crushing. Ovule growth ceased after the death of the embryo, and the ovule aborted.

This type of sterility has been reported following hybridization of species of *Nicotiana*, and also following the crossing of diploid and tetraploid races of *Lycopersicon pimpinellifolium*, and self-pollination in *Medicago sativa*. It has been suggested that the maternal tissues grow at the expense of the hybrid endosperm. As in the present material, the hybrid embryos were found to be the least altered structure of the ovule. The possibility exists that the sterility barrier may be overcome by culture of excised hybrid embryos.

Heredity and Nutrition in Relation to Magnesium-Deficiency Chlorosis in Celery. DANIEL T. POPE.

A deficiency of available magnesium has been found to be the cause of a chlorosis which has occurred on some celery varieties grown on certain organic soils. Celery developed a similar type of chlorosis when grown at low levels of magnesium in nutrient culture solutions. The differential performance of celery varieties grown under field conditions and at varied concentrations of magnesium in nutrient solutions pointed to the hereditability of the chlorotic condition. A cross between a normal parent and one expressing the magnesium deficiency symptoms and the reciprocal cross resulted in only normal F_1 plants. The F_2 population segregated into three normal to one magnesium-deficient plant. Chemical analyses of leaves and petioles of two varieties expressing the chlorosis showed significantly less magnesium than those of two normal varieties.

The Breeding System in Cotton and its Possible Significance in Methods of Cotton Improvement. S. G. STEPHENS.

Cotton (*Gossypium* spp.) reproduces itself by a mixture of cross- and self-

fertilization. The proportion of cross-pollination which occurs is chiefly determined by the frequency of pollen vectors during the flowering period. These are usually Hymenopteran species—*Bombus* spp. being of particular importance in many areas. Although the breeding system has been known for some time it is only in recent years that its possible role in breeding practice has received attention. Simple methods have now been developed to test the frequency of natural crossing in cotton fields throughout the U. S. Cotton Belt. These tests indicate (1) a variation from less than 5% in Texas to more than 50% in North Carolina, (2) little variation from season to season in any one locality, (3) considerable variation between early and "peak" flowering periods in any one season and (4) marked differences between cotton varieties. Further experiments suggest that natural crossing occurs at random. If this is the case and both the composition of an initial cotton population and the amount of natural crossing which takes place are known, it is possible to estimate the average amount of residual hybridity which will be maintained during successive seasons of open pollination. It is the normal practice of cotton breeders to mix selected strains from the same parent stock and to multiply them under conditions of open pollination in order to produce the "variety" subsequently distributed to the farmer. It is clear that the composition of such a "variety" will depend not only on the efforts of the breeder but also on the amount of natural crossing which prevails during multiplication. The "variety" could be either a mechanical mixture of the original strains or a hybrid swarm in which the identity of the original strains would be lost. If residual *hybridity* implies residual *heterosis*, the selection of strains on the basis of their combining ability in addition to other attributes might deserve more attention than it receives at present. An average residual hybridity of at least 33% should be attainable under North Carolina conditions, and hybrids are known which outyield the leading commercial "varieties" by 20 to 30%.

Plant Exploration in the Union of South Africa. R. K. GODFREY.

A recent plant exploration trip was made by the author to the Union of South Africa for the Division of Plant Exploration and Introduction of the United States Department of Agriculture. It covered the period from mid-November, 1952, to mid-March, 1953. The primary objectives of the exploration were twofold: (1) to collect seeds of forage plants, principally grasses, of potential value to the agriculture of the United States, including its territories and possessions; (2) to collect specific items of miscellaneous plant materials for chemical testing as sources of certain alkaloids and glucocides by the National Heart Institute.

The Union of South Africa ranks as one of the great grassland countries of the world. A very considerable proportion of its area is in grass, many species of which are economically important to its agriculture. In recent years some of these have been introduced in this country and of those introduced a number have proved of value for soil conservation and forage. An appraisal of the value of the species tested led to the recent further exploration in the hope that there might be found additional valuable types or more promising genetic or ecological strains of some

of them. Several hundred collections were made which are now in the process of being distributed for testing by the Division. Eventually some of these will be made available to interested workers in the southern states through the Regional Plant Introduction Station, Experiment, Georgia.

One of the experimental programs of the National Heart Institute is concerned with the search for sources in plants of drugs of possible value in treating certain heart diseases and of pharmacological testing of these drugs on laboratory animals. The Institute was interested in obtaining from South Africa some suitable material for this program. In some cases underground parts, such as bulbs, rhizomes, or roots, were desired; in others, leaves, fruits, seeds, or the whole plants. Bulbs of Amaryllidaceous plants, for example, were considered to be promising in that regard. Southern Africa encompasses an area which has one of the greatest concentrations of amaryllids known to the world. Collections were made of all of these which could be found at the particular season during which the exploration was conducted, as well as representatives of a wide range of other plant families.

Some Cytological and Anatomical Effects of Maleic Hydrazide. VICTOR A. GREULACH and JOHN G. HAESLOOP.

It is now well established that maleic hydrazide (MH) inhibits cell division. The present study, on the first internode of 28-day old tomato plants sprayed with 2000 p.p.m. MH and similar control plants, was undertaken to secure more information on its effect on cell elongation. At the time of treatment, the mean length of the first internode was 0.9 cm.; 35 days later it was 1.5 cm. in the MH treated plants and 2.6 cm. in the controls. The stem tissue was then fixed, sectioned, and stained, and measurements and counts of the cells were made. The statistical significance of the mean differences between controls and treated samples was determined by calculation of the "t" values.

The following significant effects of MH were apparent: a decrease in the mean diameter of the stem, and in the radial thickness of tissues other than the epidermis, cortex and phloem; a marked increase in the length of all but the first row of the cortical cells, apparently due to inhibition of cell division rather than elongation; a decrease in the tangential diameter of all the cortical cells, possibly due to inhibition of cell enlargement in the MH stems, or to lack of tangential stress due to growth of underlying tissues; a decrease in both the radial and longitudinal dimensions of the central pith cells; and a marked reduction in the total number of cells per internode, despite the fact that the internodes were partially expanded at the time of treatment. In these tomato stems MH caused a clear-cut inhibition of cell enlargement only in the pith. Since the major growth inhibition by MH is due to complete stoppage of mitosis in the apical meristems, and mitosis is also inhibited in elongating internodes, inhibition of cell elongation apparently plays a minor role in the total picture of MH growth inhibition.

The following additional effects of MH were noted: absence of metaxylem and secondary xylem vessels from the MH bundles; inhibition of lignification of interfasicular fiber cells; a generally disorganized arrangement of cells; and failure of cells to wrinkle as usual during fixing and staining of the tissues. The collapse

of phloem elements noted in several other species treated with MH by other workers was not observed in these tomato stems.

Translocation of P^{32} Injected by Myzus persicae *(Sulz.) into Tobacco Plants.* F. R. LAWSON, G. B. LUCAS, and N. S. HALL.

Green peach aphids fed upon tobacco plants treated with phosphorus containing P^{32} became radioactive and the tracer was found in their honeydew or feces, in or on cast skins and young born of radioactive mothers. It was also found in leaves on which these aphids had fed and where it was probably inserted as a part of the salivary secretions. The P^{32} inserted into the leaf by the aphids was translocated to other aerial parts of the plant.

It is concluded that part of the injury caused by *M. persicae* to tobacco may be due to injected salivary secretions absorbed and translocated by the plant.

A New Houstonia from Chatham-Randolph County, N. C. HOLLIS J. ROGERS.

On March 27 and April 1, 1953, Miss Mary Overman of Greensboro brought me specimens of a white flowered *Houstonia* L. These plants were collected on the farm of Mr. L. H. Fogelman on the South Prong of the Rocky River, 2½ miles northeast of Staley, and near the Chatham-Randolph County lines. I visited this area on April 24, collected specimens, photographed the plants, and observed them over a distance of about one mile.

These white bluets grew in the same habitat as *H. patens* Ell. and showed the same general growth habit as this species. They differed conspicuously in the field in flower color, in the size of the flowers, and in the shape of the petals. The basal leaves were more ovate in shape and mature plants were considerably larger. *H. caerulea* L. was also in the vicinity, but grew in the more shaded areas. This plant differs from *H. caerulea* forma *albiflora* Millsp. in growth habit, and lacks any semblance of the characteristic yellow eye.

The white flowers turn blue upon drying, and general shrinkage will make herbarium determination most difficult unless some other characteristic can be discovered. Seeds have been collected for study and culture in hopes that a more definite report can be made next year.

The Clay Minerals and the Iron Oxide Minerals of the Triassic "Red Beds" of the Durham Basin. W. GARY HOOKS AND ROY L. INGRAM.

The clay fraction of 50 samples of Triassic "red beds" were analyzed by X-ray diffraction techniques. Illite is the most abundant clay mineral. Montmorillonoids and kaolinite are quantitatively of secondary importance. The illite is probably a product of the diagenesis of clastic kaolinite incorporated in arkosic sediments with a high potassium content. The "red beds" vary in color with different shades of red, brown, pink, orange, and yellow being common. It is probable that the variations in the size of the hematite grains is responsible for the variations in the color of the "red beds" since hematite is the only crystalline iron oxide present. The red color is most probably the result of rapid erosion and deposition of red soils under warm humid conditions.

Why the "Whiteness" of White Lake, Bladen Co., N. C. B. W. WELLS and STEVE BOYCE.

Frey in his studies of the Bladen Lakes states that the clarity of White Lake is due to "the drainage pattern. The outlets of Jones, Salters, Singletary and Black Lakes all occur toward the southeast or southwest end of the lake away from the region of maximum bay and peat formation at the northwest end. . . . In White Lake the outlet is located at the northwest end. Consequently, heavy precipitation is drained away from the lake rather than through the lake."

Suspicion is cast on this theory by the fact that during extended drouth periods (as during the summer of 1952) there is no outflow through the one drainage outlet. Under these conditions the water next the bog should become colored, but no darkening was observed. The drainage at all times is very slow, for the outlet is not a stream but a mere man-made connection with a Carolina Bay bog.

Frey has ignored the reports of heavy bottom artesian inflow. One of us (Wells) many years ago happened to pass over the point of intake where the large volume of water entering was indicated by the boiling sand. An indirect method of proving the artesian source of the lake water was carried out last summer. During the drouth when there was no outflow through the one drainage outlet, and under quiet weather conditions, a demonstration was obtained of the lake water moving into the porous sands of the shore. The intense dye fluorescin was put into a spade-made well near the southwest lake margin. In 24 hours this dye had been moved out of this well and was but faintly detected in a well eight feet inland from the first well. An intermediate well 3 ft. from the first also tested clear. It is this constant pressure of clear artesian water against the lake margin which explains the "Whiteness" of White Lake.

The Establishment of a Seismological Observatory at Chapel Hill. G. R. MACCARTHY.

A pair of Sprengnether series DH long period horizontal component seismometers, together with the necessary recording and timing devices, have been secured by the University of North Carolina, and mounted in a specially constructed vault in the basement of New East Building. These seismometers have been in intermittent operation for several weeks, but final adjustments are still in progress so that routine work with them is not yet possible. The first earthquake recorded was that of March 19, 1953. At that time the instruments were being operated at such high magnification that the light beam was swung clear off the paper and the mirrors of both recording galvanometers stuck, so that much of the record was lost. The equipment is now being readjusted, and it is hoped that routine reporting of distant earthquakes can begin within a very short time.

As far as known, this is the first seismological station to be established in North Carolina. The nearest one to the south is at Columbia, S. C., and there are several at Washington, D. C. To the west the nearest stations are at Cincinnati, Ohio, at St. Louis, and at Morgantown, West Virginia, so that the establishment of this station at Chapel Hill fills a serious gap in the seismological coverage of the eastern United States.

Chemical Analyses of Ground Water as an Aid to Mapping the Tertiary Limestone Unit in North Carolina.[1] H. E. LEGRAND.[2]

Limestone of Tertiary age forms a distinctive unit in the Coastal Plain sediments of North Carolina. This unit is most prominent in a triangular area whose western, southern, and eastern extremities are formed by Duplin, New Hanover, and Carteret Counties, respectively. It occurs chiefly as a shallow subsurface wedge that dips and thickens slightly to the east. Factors that heretofore have made its position and extent difficult to ascertain include the scarcity of outcrops, the scarcity of reliable data concerning wells that penetrate it, and the removal of part of the limestone by solution causing great irregularities in its thickness and areal extent in up-dip areas.

The great water-yielding capacity of the limestone indicated by the meager available data has led to the current ground-water investigation of the area in which it occurs, being made as a part of the study in cooperation between the United States Geological Survey and the North Carolina Department of Conservation and Development. A more accurate mapping of the limestone unit, therefore, has become necessary. The present ground-water studies show that the distinct difference between the chemical character of water from the limestone and that of water from the overlying and underlying sands provides a useful means of mapping the limestone unit. The water from the limestone is alkaline and hard, the hardness being due chiefly to calcium bicarbonate. Water from the overlying sand is soft and somewhat acid. Water in the sands underlying the limestone is a soft sodium bicarbonate water, except in places near the coast where the chloride content is high. Thus, a relatively simple test for hardness is adequate to make a distinction between the water in the limestone and that in the overlying and underlying sands; in addition, the corrosiveness of the water in the overlying sand generally can be detected by the deterioration of water pipes and the presence of "red water." Field tests of hardness and notes on corrosiveness of water from wells of known depths are helping to delineate the limestone unit, in addition to indicating the chemical quality of the local ground water. Field tests for hardness made of the headwaters of many streams were successful in showing the extent to which streams have incised the limestone unit. The tests were made during the drought of 1952, when all stream flow came from ground water that discharged from the surficial sands or underlying limestone, or from both.

Submarine Canyons—Where are they Located off the Coast of North Carolina. DUNCAN HERON.

No submarine canyons have been located off the coast of North Carolina that head up in water as shallow as 100 fathoms. Off Cape Fear the slope of the shelf under 30 fathoms varies between 2 and 8 feet per nautical mile. The slope between 30 fathoms and 300 fathoms averages about 40 feet per mile. This is in decided contrast to the sharp grade of the continental slope off the coast of Virginia and Maryland. The change of grade between the shelf and slope is not well defined

[1] Publication authorized by the Director, U. S. Geological Survey.

[2] District geologist, Ground Water Branch, U. S. Geological Survey, Raleigh, N. C.

southeast of Cape Fear, as shown by available soundings. The most prominent break occurs at around 30 fathoms. No conclusions have been reached as yet to explain such a gradual slope in the Cape Fear area, but it would seem that the lack of a steep slope would be detrimental to the formation of submarine canyons. Detailed contouring cannot be accomplished with the information available at this time.

Chance of Observation in Geology. E. C. VAN HORN.

Chance of observation in geological reconnaissance can easily nullify the values of findings which are secondary to the basic objective of the reconnaissance; and attempts to extend reconnaissance findings as detailed criteria very often constitute misinformation which may deter an understanding, and therefore a useful application, of secondary factors.

Chance of observation also maintains interest in areas which supposedly have been examined extensively, giving rise to unexpected discoveries previously overlooked.

Striking examples are represented in the tungsten deposits of the Townsville area, in the sillimanite of western North Carolina, and in the lithology and structure of the Murphy marble belt.

Clay Minerals of the Tuscaloosa Formation near Fayetteville, N. C. ROY L. INGRAM.

The clay fraction of 5 sandstones from the Cretaceous Tuscaloosa formation near Fayetteville, N. C., were analyzed by X-ray diffraction techniques. Kaolinite is the most abundant clay mineral in the samples studied. Kaolin-type chamoisite, illite, and montmorillin are present in small amounts in a few of the samples. Mixed-layered aggregates, possibly of illite and montmorillin, are found in varying amounts in each of the samples.

Investigation of Limestone in Eastern North Carolina. JASPER L. STUCKEY.

In December 1949, a cooperative agreement was entered into by the N. C. Department of Conservation and Development, the N. C. Highway and Public Works Commission, and the N. C. Department of Agriculture for the investigation of limestone resources in eastern North Carolina as a possible source of cement material. The investigation was carried out under the direction of a committee, composed of Jasper L. Stuckey, State Geologist, as chairman; H. W. Jordan, Chairman of the Highway and Public Works Commission; and L. Y. Ballentine, Commissioner of Agriculture. G. W. Moore, an engineer with considerable experience in cement materials and cement manufacture, was employed to carry out the field work under the supervision of the State Geologist.

Information available in the Division of Mineral Resources indicated that the Coastal Plain is the division of the State most likely to contain limestone suitable for the manufacture of cement. Accordingly, work was centered in the Coastal Plain. Careful field work over a period of months has indicated that large tonnages of soft limestone, commonly known as marl, of a composition ideally suited to the manufacture of portland cement may occur in the vicinity of Maple Hill

in Pender County. Preliminary drilling indicates that the limestone varies from 20 to 40 feet in thickness with an overburden that varies from two to eight feet. The following analysis is typical: SiO_2, 3.3%; Al_2O_3, 1.0%; Fe_2O_3, 0.8%; CaO, 50.7%; MgO, 0.9%; CO_2, 42.2%; and P_2O_5, 0.11%—Total, 99.01%.

The Nineteenth International Congress, Algiers, September, 1952. E. WILLARD BERRY.

The International Geological Congresses are held every four years. The next will be in Mexico in 1956. Between 1500 and 2000 people registered from some seventy-seven different countries. We met in the assembly halls and class rooms of the University of Algiers. The business meetings had simultaneous translation service, but the scientific papers were in French or English. The various trips, both before and after the Congress, were well planned and carried out. The numerous publications given were well worth many times the registration fee.

Professor Charles Jacob of Paris was elected President, succeeding H. H. Reed of London. The Governor General, M. Roger Leonard, entertained us at the Palace, a very colorful gathering with the Arabian guards in flowing robes and with drawn swords. Most of the cities visited before and after the Congress also entertained us—usually a hot and dirty mob of field men. It was quite a five to six weeks' experience for all of us.

The Clay Minerals of Neuse River Sediments. CHARLES Q. BROWN AND ROY L. INGRAM.

The clay fraction of 31 samples of Neuse River sediments were analyzed by X-ray diffraction techniques in order to determine the clay minerals that characterize the sediments and to determine the diagenetic changes in a stream environment. Kaolinite, illite, montmorillonoids, "chlorite," and mixed-layered aggregates were identified. Kaolinite is the dominant mineral but decreases downstream. Illite and montmorillonoids occur sporadically throughout the length of the stream. A chloritic mineral is found in the lower part of the stream and in the upper part of the estuary. This mineral is similar to chlorite in that it gives a 14 kX basal spacing that does not shift with glycerol or ammonium chloride saturation but dissimilar in that the 14 kX spacing is altered by heating at 550° C. Mixed-layered aggregates, possibly of illite and montmorillonoids or of illite and chlorite, occur throughout the length of the stream but increase in abundance downstream. Amorphous material is common or abundant in nearly all of the samples. Because of the large number of possible sources for different clay minerals, definite conclusions cannot be made as to clay diagenesis. However, it is probable that kaolinite and montmorillonoids are partially altered to "chlorite" and mixed-layered aggregates.

Preliminary Geology of the Southwest Part of the Raleigh Quadrangle, N. C. JOHN M. PARKER, III.

The southwestern quarter of the Raleigh quadrangle, N. C. is underlain by a generally northeastward trending series of interbedded meta-sedimentary and

meta-volcanic rocks. Biotite gneisses with subordinate hornblende gneiss layers predominate; less common varieties include graphite schist, garnet-kyanite schist, staurolite schist, meta-conglomerate, meta-quartzite, and phyllitic tuff. Grade of metamorphism increases eastward toward granite. Granitic sills, microcline-quartz pegmatites, and diabase dikes are common. Quartz veins are very numerous. Quartz-tourmaline, quartz-specularite, and quartz-muscovite-carbonate veins occur sparingly.

The Volume of a Portion of a Cylindrical Tank with Spherical Ends. ANNE LEWIS.

Given a cylindrical tank with spherical ends, where the radius of each sphere is twice the radius, r, of the cylinder, and the length of the whole tank is known, it is desired to find the volume occupied by the liquid in the tank between two given depths. It is first shown how to find the length of the cylindrical portion of the tank, so that the volume of the liquid in that part of the tank can be calculated. Then it is shown how to find the volume of the liquid in the spherical end portions by means of a double integration. The final integration is accomplished by using a substitution of the form $\sqrt{r^2 - x^2} = x/t$.

An approximate solution for the specific instance from which the general problem had originated is also given, and the results of this approximation and the integral solution are compared.

An Algorithm for the Diagonalization of a Symmetric Matrix. H. M. NAHIKIAN.

The algorithm developed in this paper is based on the following well known theorem: Two matrices are congruent if and only if one is obtainable from the other by a succession of pairs of elementary operations, each pair consisting of a column operation and the corresponding row operation. In each pair either operation may be performed first.

If A denote the given symmetric matrix and if E_i, $i = 1, 2, \cdots, k$ denote the elementary operations on the columns of A and E_i', $i = 1, 2, \cdots, k$ denote the corresponding elementary row operations, then there exists a set of matrices E_i such that $P'AP = N$, where N is diagonal, $P = E_1E_2 \cdots E_k$ and $P' = E_k'E_{k-1}' \cdots k_1'$. Hence the matrices P and P' may be constructed mechanically keeping track of the steps by means of "counters". The method may be extended to Hermitian matrices using elementary column operations E_i and the corresponding conjunctive row operations $\bar{E}_i'$.

On the Least Primitive Root of Certain Primes. ALFRED BRAUER.

Let p and q be odd primes and $p = 2^tq + 1$. It was proved by H. -J. Kanold in 1950 that for sufficiently large primes p of this form the least positive primitive root $g \pmod p$ is less than $p^{1/2}$. In this paper the following better result is obtained. If q is greater than $\max\{11, 2^{t-1}(3 + 8^{1/2})\}$, then g is less than $p^{1/2}$. Moreover, it is proved that in the special case $t = 1$ the least positive primitive root is less than $(2p)^{2/5} + 3(2p)^{1/5} + 1$. For the proof a theorem of the author on the least quadratic non-residue published in 1930 is used.

The Polarizing Process and its Inverse as Applied to General Surfaces. A. T. CURLEE.

Let $\varphi(x, y, z) = 0$ be made up of a finite number of terms of the form $A_i x^p y^q z^r$ where p, q, and r are real. Let $P_1(x_1, y_1, z_1)$ be a non singular point on $\varphi(x, y, z) = 0$, where P_1 is not on a coordinate plane, such that φ and its first partial derivatives are continuous at P_1. Transform $\varphi(x, y, z) = 0$ into $\bar{\varphi}(x', y', z') = 0$ with the polarizing transformations. Do this in any manner that will give a real surface $\bar{\varphi}(x', y', z') = 0$, which is also continuous along with its first partial derivatives at P_1.

The surface represented by $\bar{\varphi}(x', y', z') = 0$ will be tangent to the one represented by $\varphi(x, y, z) = 0$ at P_1.

Next let $\varphi(x, y, z) = 0$ be rational and integral in the variables and let it be of degree n. Make the second degree transformations as far as possible, and follow by a linear one when necessary. If n is even $\bar{\varphi}(x', y', z') = 0$ will be of degree $\frac{n}{2}$, and if n is odd $\bar{\varphi}(x', y', z') = 0$ will be of degree $\frac{n+1}{2}$. Hence the process may be repeated until the tangent plane at P_1 is obtained.

These transformations may be applied to transcendental surfaces with the result that the transformed surface will be a tangent surface provided similar conditions to those stated above are fulfilled.

Under the same restrictions the inverse transformations which are $x' = 2x - x_1, y' = 2y - y_1, z' = 2z - z_1; x' = \frac{1}{y_1}xy - \frac{x_1}{y_1 z_1}yz + \frac{1}{z_1}xz, y' = \frac{1}{x_1}xy - \frac{y}{x_1 z_1}xz + \frac{1}{z_1}yz, z' = \frac{1}{x_1}xz - \frac{z_1}{x_1 y_1}xy + \frac{1}{y_1}yz; x' = \frac{x^2}{x_1}, y' = \frac{y^2}{y_1}, z' = \frac{z^2}{z_1}$, may be applied to any of the above surfaces with the result that the transformed surface is a tangent surface at P_1.

Egg Production and Hatchability in the Wasp Habrobracon. D. S. GROSCH.

A bimodal or polymodal shape of the curve suggested for braconid egg production plotted in days is of significance in comparison with the oviposition records of irradiated females. The second week low corresponds not only to the drop in production induced by substerility doses but also to the nonproductive period in temporary sterility and to the onset of nonproduction in permanent sterility.

Prestarvation, known to affect oosorption, is a necessary preliminary to our ingestion experiments with radioactive isotopes (A.E.C. Contract No. AT-(40-1)-1314). The bimodal suggestion was obtained with 160 untreated animals used as controls and hence prestarved. Therefore an experiment was set up with 35 unstarved females newly emerged from the cocoon in which it was found that without prestarvation more than one mode may be expected in the laying curve. Furthermore, suspected polymodal curves plotted on probability paper gave sigmoidal inflections indicative that the irregularities are not due merely to sampling errors. A caution pertaining to the grouping of data is that curves from different animals or from different samples may be out of phase and polymodality may be thereby obscured.

Although egg laying curves from individual *Habrobracon* are difficult to classify by inspection, over 50% of those examined appear to have two or more modes. Likewise the meager evidence on egg production by other ectoparasitic braconids can be interpreted as bi- or polymodal in type of curve. Discussion advanced the possibility of a clutch-deposit physiology.

The senile decline in hatchability very clearly demonstrated in unfertilized eggs from *Habrobracon* refocusses attention on the female gamete. No sperm are required here to trigger embryogenesis. Hypotheses to explain decline in the percentage of hatchable eggs produced by aging *Drosophila* and domestic fowl have featured strongly the supposed role of the male gamete.

Injection Experiments with Vital Dyes; Habrobracon Larvae Fed on Dye-Injected Hosts. R. L. SULLIVAN AND D. S. GROSCH.

Recently, aniline blue, Prussian blue, light green and Sudan III have been tested as vital dyes by injections into paralyzed *Ephestia* caterpillars, the standard host for rearing *Habrobracon*. The dyes were in 1% aqueous solution except for the Sudan III which was in glycerin. These are additions to the total of 31 dyes previously considered by Campbell (1932 J. Econ. Ent.) on silkworms and Grosch (1952 Biol. Bull.) on *Ephestia*. Neutral red remains the least toxic of dyes introduced into the physiological interior of insects and is the only dye thus far reported to be excreted by way of the silk. Our experience has been with 6,057 prestung *Ephestia* larvae injected with various dilutions of neutral red and P^{32} at the rate of 30 to 100 per day during the period of January through May of 1953. However we have been puzzled by the deterioration of a fraction of our injected caterpillars. Exploratory experiments have compared dilutions of 0, 20, 40, 60, 80% of the dye in Ringer's solution and in tap water with injections of the diluents alone using the same capillary needle. Three replications were made at each dilution, totalling 35 caterpillars. No significant differences in deterioration were found correlated with dilutions. Instead we now suspect size of the capillary needle and faulty insertion. One particular danger may be puncture of the digestive tract.

A further recent discovery is that unstung caterpillars regularly decolorize neutral red and that decolorizations in stung caterpillars may be traceable to incomplete paralyzation.

The Ecological Distribution of Spiders in Non-Forest Maritime Communities at Beaufort, N. C. ROBERT D. BARNES.

Variation in the saline water table is a prime factor in determining the formation of the major maritime plant communities and the zonational and successional series in which they occur. On the coast of North Carolina the zonation and succession of vegetation consist of the following series of communities beginning in the intertidal zone and ending in the climax maritime forest: *Spartina alterniflora*, *Spartina patens*, mixed herbaceous, *Myrica-Ilex Quercus* shrubs, *Persea-Ilex-Quercus* shrubs and the maritime live oak climax. Also characteristic of the coastal area are the estuarian *Juncus Roemerianus* and *Spartina-Distichlis-Salicornia* communities as well as the dune grass *Uniola paniculata*.

The structure of the spider populations was determined for each of these communities with the exception of the forest climax. The investigation was carried out at Beaufort, N. C. during 1951 and 1952.

A total of 139 species of spiders belonging to 24 families was collected in these maritime communities. Each community displays a distinct population structure characterized both by the presence of certain species and by the relative density which each exhibits. From intensive sampling in one community, *Spartina alterniflora*, there is evidence that this structure is relatively constant both in space and in time.

The zonation and succession of maritime vegetation produces a zonation and succession of spiders beginning in the intertidal communities and ending in the maritime forest. This succession, in general, is characterized by an increasing number of species and population density with proximity to the maritime climax. This may in turn be correlated with the increase in stratification of the intracommunity environment and the greater number of ecological niches afforded by the vegetation.

Swimmer's Itch in Alaska. REINARD HARKEMA.

Certain schistosome cercariae of bird or mammal origin are capable of penetrating into the skin of man producing a dermatitis characterized by papular eruptions and intense itching. Man is exposed to the cercariae when swimming, bathing or wading in infested water.

The survey of Alaskan schistosomes (blood flukes) of military-medical importance resolved itself into a collection of snails which are the intermediate hosts of the worms and which release infective penetrating cercariae. A total of seventy-six bodies of water was investigated during the summer of 1952. Sixteen were found to harbor snails infected with the itch-producing cercariae. Infested sites were in the Fairbanks area, Yukon flats, near the Tok and lower Alaska Highways. Ten species of snails were found and the two most common species, *Lymnaea palustris* and *L. stagnalis*, were found to harbor the cercariae.

The highest incidence of schistosome cercariae was in late July and August. This is probably correlated with the life cycles of the snails, which may become infected during the fall of the year just prior to hibernation. After overwintering the snails and the larval stages of the schistosome mature and the cercariae are liberated during the summer.

Natural clinical cases of schistosome dermatitis were found and the itch-producing ability of the located cercariae was demonstrated in all instances. The general syndrome of schistosome dermatitis is discussed.

A limited study of the morphology of the cercaria is presented and the behavior of the liberated cercariae is discussed. Additional morphological, ecological and life history studies are necessary before positive identification can be made. (This work was supported by the U. S. Air Force and Arctic Aeromedical Laboratory, Ladd Air Force Base, under AF Contract No. 18(600)-187 between North Carolina State College and the Air Research and Development Command.)

Studies on Host Tissue Reaction to Chigger Bite. J. R. C. BROWN AND G. W. WHARTON.

Chiggers were permitted to attach to the shaved belly of an anesthetized hamster while under close observation with a dissecting microscope in order to determine exact time of attachment. At timed intervals biopsies of hamster skin with chigger attached were removed and fixed. Serial sections were prepared from these biopsies. Study of these sections showed the initial stages of penetration of the chelicerae, injection of salivary secretion after approximately twenty minutes, erosion of the tissues beginning after about forty-five minutes, and formation of the stylostome or sucking tube in the host tissues. The keratinized layer of the epithelium is not digested, but nonkeratinized epidermis and dermis are digested in the region of the bite. Tissue reaction is observed at some distance beyond the actual dissolution of the tissues. Tests on man indicate that if the chigger is allowed to remain attached as long as one hour, the typical reaction develops and persists for one or more days, even though the chiggers are removed.

The Wild Bird as a Factor in Breeding Attractive Flowers. A. L. PICKENS.

The question of a favorite color with humming-birds and other birds seeking food has long interested naturalists. Over a period of twenty-six years a list of five hundred kinds of flowers observed to draw birds has been collected by observation, reading, correspondence, and conversation with nature-students. Red seems a prime favorite with violet and orange following. As the list grows, white and yellow, by sheer numbers, are riding down violet and orange, the red-kin colors. Red, however, though comparatively rare in nature, from the beginning assumed a lead that it still maintains, even when pink is separated as another group. Maroons,—here in their true meaning of "chestnut" or brownish tones,—however, have as consistently occupied last place. Others shift, the order now standing: Reds, whites, yellows, violets, pinks, blues, oranges, greens, maroons. The mint and scrophularia families furnish more species, the leading genera being *Penstemon* and *Salvia*. Humming-bird flowers closely resemble bee and butterfly flowers. Curiously enough, near the west coast, the carpenter-bee flower, *Audibertia polystachya*, is pilfered by honey-bees without working the complex pollinating arrangement, though Costa humming-birds can do so, while near the east coast, the leaf-cutter bee flower, *Strophostyles helvola*, in the form *S. helvola bellemeadensis*, with broader leaves, smaller flowers, and a duller pink color seems catering to some still smaller bee or insect, though *Erythrina herbacea* of the same family has evolved as a humming-bird flower. Insects are limited in color distinction; some seem not to see red. Red and red-kin colors afford most contrast against green, and in the developing of gorgeous wild flowers the bird's red-seeking instincts unquestionably must be considered.

Pygmy Sunfishes and the Meaning of Pygmyism. THEODORE H. EATON, JR.

The two southern coastal plain pygmy sunfishes, *Elassoma zonatum* and *E. evergladei*, constitute a family, Elassomidae, evidently derived from Centrarchi-

dae. Most but not all of their distinctive features can be accounted for by the delayed or inhibited development of specific structures: lack of bone enclosing sensory canals on head; elimination of parts of head canal system and reduction in number of pores; absence of lateral line on body; lack of ridges, crests or serrations on skull bones; cartilaginous ethmoid and parethmoids; relatively large eyes, nasal cavities, head canals, and brain; simplified olfactory organ; elongate rather than deep body; reduction of dorsal spiny rays to 4 or 5; absence of inclinator muscles for spiny rays; gill membranes connected across isthmus; absence of pyloric ceca.

In other respects they agree with typical adult sunfishes: structure of jaws and suspensorium; jaw musculature and associated ligaments and tendons; detailed structure of fin rays and pterygiophores; relative size of anterior pituitary; reproductive organs.

Since there are several ways in which the size of an adult animal may be prevented from reaching that of its close relatives, it is suggested that the term *pygmy* be restricted to cases in which reduced size is hereditary and is normal for a population (race, subspecies, species, genus, or family) as compared with other related populations of similar rank. A *dwarf*, in contrast, is an individual smaller than others of its own population. Dwarfism may either be genetically controlled (but in that case occurs in a small minority) or not (it is then due to stunting or to simple endocrine deficiency).

Habitat and Territory in Macgillivray's Seaside Sparrow. T. L. QUAY.

The habitat, territory, and behavior of the Seaside Sparrow (*Ammospiza maritima macgillivraii*) were studied for six summers (1946–1951) on selected plots at Beaufort, N. C. The principal plot was a 47-acre island of mixed salt marsh and sand dune, which was completely mapped for vegetation, topography, and Seaside Sparrow territories. The Seaside Sparrow populations on this plot for the six seasons were: 1946—19 pairs, 1947—26 pairs, 1948—29 pairs, 1949—33 pairs, 1950—38 pairs, 1951—39 pairs. Territory size varied between 0.35 and 1.10 acres. These Seaside Sparrows were multi-brooded and strongly territorial, with a distinctive flight song. The nest was placed a few inches off the ground in the herbaceous vegetation just above the drift line, and occasionally was flooded on unusually high tides. Color banding of nestlings was done in 1951.

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY

1952–1953

498TH MEETING, OCTOBER 14, 1952

CHARLES N. REILLEY (Chemistry): *Principles of High-Frequency Titrimetry.*

The concepts for the interpretation of high-frequency titrimetric methods previously based upon the Debye-Falkenhagen effect are abandoned in favor of a macroscopic equivalent circuit analogy in order to describe the electrical behavior of the cell and its solution. Each of the factors influencing these electrical properties is studied by comparison of derived equations and experimental data. Effects studied include frequency, geometric factors, such as thickness of cell walls, area and separation of electrodes, as well as chemical factors influencing the conductance of solution such as degree of ionization, the chemical reaction, ionic concentration, and solvent differences.

Transfer plots, obtained from experimental data, are found to agree with the shape expected theoretically. By use of these transfer plots all apparent anomalies in the shape of the high-frequency titration curves are correlated with the shape of the corresponding D-C conductance titration curves of the solution. Because the titration curve shape is determined quantitatively by the transfer curve, undesirable end-point characteristics may be avoided by proper dilution, addition of foreign electrolyte, change of frequency, or by use of a cell with the proper geometric characteristics. The interpretation of high-frequency titration curves is facilitated by means of this analogy which focuses attention on the underlying variables affecting the results. This viewpoint should therefore prove valuable in the extension of high-frequency methods to new analytical problems.

JAMES A. GREEN (Anatomy): *Secretion of Progesterone in the Absence of Luteal Tissue in Immature Mice.*

Pregnant mare serum gonadotrophin in amounts ranging from 0.07 to 240 ug. was given in single subcutaneous injections to 21-days old female mice of the Strong A strain. Luteinization of the ovaries occurred in all of the animals given 1.1 ug. or more of the preparation. Below this dose level ovarian weight and morphology were essentially the same as in the untreated control animals, but uterine weight and morphologic changes indicated secretion of both progesterone and estrogen over the entire range of doses.

Another series of mice of same age were given single injections of 1.1 ug. of the same gonadotrophin and killed 12, 24, 36, 48, 72, and 120 hours later. Changes in the stromal nuclei of the endometrium indicated the action of progesterone after 12 hours and throughout the test periods. Slight heightening of the luminal epithelium of the uterus and a trace of endometrial edema indicated the action of trace amounts of estrogen at 12 hours. Intensification of these uterine changes indicated gradual increase in estrogen to a peak at 60 hours, followed by a de-

cline. It is apparent that estrogen and progesterone were promptly secreted after administration of gonadotrophin and in the absence of recognizable morphologic change in the ovaries.

Adrenal participation in eliciting uterine changes in these animals was ruled out by absence of uterine changes in ovariectomized mice given the same gonadotrophin and examined 72 hours later.

499TH MEETING, NOVEMBER 11, 1952

LEON D. FREEDMAN (Experimental Medicine): *Preparation and Biological Properties of Aromatic Phosphorus Compounds.*

Relatively few organic derivatives of phosphorus have been investigated as therapeutic agents. Research on these compounds has been hindered by a lack of convenient synthetic methods. About two years ago a paper from this Laboratory described a new synthesis of arylphosphonic and diarylphosphinic acids by the reaction between diazonium fluoborates and phosphorus trichloride in organic solvents. This method makes readily available a wide variety of organophosphorus compounds which hitherto have been difficult, if not impossible, to obtain. We have prepared about seventy phosphonic and phosphinic acids, the majority of which have not been previously described.

All of these compounds are being tested against a large variety of microorganisms. Thayer, Magnuson, and Gravatt have already published some of the results. In the concentrations used 15 of the 29 phosphonic acids tested inhibited the growth of one or more bacterial species employed; and 16 of the 23 phosphonic acids tested possessed some activity. In general, the phosphorus compounds were much less effective than sulfathiazole. Phosphanilic acid was the most active phosphorus compound tested. It was effective against eight of the bacterial strains used; against some of these it was almost as active as sulfathiazole. Several of the phosphorus compounds had a wider antibacterial spectrum than phosphanilic acid but were not as potent. Preliminary studies in mice on the toxicity of these compounds indicate that they are rather nontoxic. The LD_{50}'s ranged from 1 to 9 gms./kg.; the average LD_{50} was about 4 gms./kg. Phosphanilic acid was one of the least toxic. On a molar basis, phosphanilic acid was only one-ninth as toxic as sulfathiazole and one-third as toxic as sulfanilamide.

We have also investigated the cholinesterase inhibitory properties of phosphonic and phosphinic acids. Most of these compounds caused little or no inhibition at 0.003 M and were not further studied. A few, however, were active at much lower concentrations. The most active acid caused fifty per cent inhibition at a concentration of 6×10^{-5} M. Several esters of phosphonic and phosphinic acids were also prepared. Most of the esters were more active than the free acids.

PAUL L. BUNCE (Surgery): *Some Factors in Prostatic Growth.*

The androgen dependence of prostatic tissue has been demonstrated many times. To investigate further the mechanisms involved in this reaction immature male albino rats were subjected to castration and to castration combined with hypophysectomy. Prostatic weights were used in comparing the effects of varying

dosages of injected androgens and estrogens. The prostatic response to androgen was always reduced in the hypophysectomized-castrate group. A.C.T.H., thyroxine, and prolactin were then given to a group of hypophysectomized castrate rats maintained on a standard androgen regime. The hypophysectomized castrate rats injected with androgen and prolactin developed prostates of approximately the same weight as the castrate controls receiving the same amount of androgen.

500TH MEETING, DECEMBER 9, 1952

ARCHIBALD HENDERSON: *Science and Art: Some Sparks from the Forge of Life.*

Prior to the meeting, the Executive Committee of the Society entertained Dr. Henderson, as well as Dr. Cameron, Dr. Hickerson and Dr. R. E. Coker, as Emeritus or Honorary Member of the Society, at dinner at the Carolina Inn.

501ST MEETING, JANUARY 13, 1953

J. F. BUNNETT (Chemistry): *Resolution of Racemic Substances by means of Optically Active Polymeric Materials.*

Various workers have achieved partial resolution of racemic substances by fractional adsorption on naturally occurring optically active solids such as cellulose, wool and D-lactose, but previously no synthetic optically active polymers had been used in such experiments.

Cross-linked phenol-formaldehyde type polymers were prepared from N-p-toluenesulfonyl-L-tyrosine and from both antipodes of β-(p-hydroxyphenyl)-butyric acid. No substantial amount of racemization occurred during polymerization or during subsequent treatments which the polymers received. The optically active resins were placed in columns and solutions of racemic α-pipecoline, α-methylbenzylamine and other amines passed through slowly in the hope that optical isomer might be preferentially bound to the resin. The first samples of amine which broke through were, however, devoid of optical activity.

The failure to obtain resolution in these experiments probably relates to insufficient specificity of interaction of the asymmetric amine molecules from the solution with the acidic groups of the polymers. It is to be expected that, for resolution to be achieved in such systems, there must be a highly specific steric interaction such that one antipode will "fit" with the polymer and the other will not.

C. BRUCE TAYLOR (Pathology): *Experimental Atherosclerosis and its Possible Relationship to the Human Disease.*

At present over half of the deaths in the United States are attributable to cardiovascular diseases. It appears that the major form of cardiovascular disease, atherosclerosis, is approaching its final solution and eradication.

Arteriosclerosis is a general term for so-called degenerative diseases of arteries. Atherosclerosis is classified as a form of arteriosclerosis. Another common form of arteriosclerosis is hyperplastic intimal thickening which results from a unique process of repair of areas of degeneration and injury in walls of arteries. New vascular tissue is formed on the inner lining of the arteries instead of forming new tissue within the wall at the sites of injury. This type of repair process which

appears to occur gradually over many years in man results in some narrowing of lumina and thickening of walls of arteries. This change in vessels plays essentially no part in lethal forms of vascular disease.

Atherosclerosis is a disease characterized by the deposition of lipids in the intima and inner media of arteries. Vessels commonly affected are the coronary arteries, the aorta and arteries in the brain and lower extremities. It has been known for forty-five years that feeding cholesterol and fats to vegetarian experimental animals produces atherosclerosis. An elevation of cholesterol in blood is associated with the development of atherosclerosis. Elevation of cholesterol in blood also markedly impedes normal healing processes in arteries. Atherosclerosis also narrows lumina of arteries. It appears to act as a foreign body causing degeneration, ulceration and hemorrhage with subsequent thrombosis and complete obstruction of arteries.

In experimental animals atherosclerosis is reversible if fats and cholesterol are eliminated from the diet. In certain population groups, eating one-third to one-sixth of the amount of fat eaten in the United States, atherosclerosis is rare.

Atheroclerosis in man is a slowly progressive disease that begins in childhood. The disease rarely becomes marked enough to cause a critical illness until males are over thirty and females are over fifty years of age. It is difficult to visualize large groups of individuals making permanent restrictions in their dietary intake of fats and cholesterol at twenty years of age in order to avoid possible coronary thrombosis some ten to thirty years later.

502ND MEETING, FEBRUARY 3, 1953

C. B. METZ (Zoology): *The Fibrillar Systems of Ciliate Protozoa as Revealed by the Electron Microscope.*

The primary fibrillar system of ciliate Protozoa, as revealed by the light microscope, consists of a number of parallel units, the kineties. Each of these is composed of 1) a longitudinal row of cilia, 2) a longitudinal row of small granules (the kinetosomes), one at the base of each cilium and 3) a longitudinal ectoplasmic fiber (kinetodesma) which connects all the basal granules in the row. By appropriate technique (sonic dissection of fixed animals) fragments of the pellicle of ciliates with the associated kinety systems were prepared for electron microscope study. *Tetrahymena geleii* and several species of *Paramecium* were examined. The kinety systems of these organisms are remarkably similar in structure. In the paramecia the cilia pass through ring-like thickenings in the pellicular membrane and terminate at the kinetosomes in the ectoplasm of the animal. The kinetodesma is not a single fiber connecting all kinetosomes in a row, but consists of a bundle of fine fibrils. Each of these component fibrils arises independently from a ciliary basal body and joins the bundle of similar fibrils. Each fibril extends for approximately 5 interciliary units as a member of the bundle and finally tapers to a fine point. The fibrils contain a spiral structure with a period of approximately 400 Å. Except in the highly complex oral region the kinetodesmal fibrils are highly polarized. They all pass toward the anterior of the animal. The fibrillar system of *Tetrahymena* is similar to that of *Paramecium*. Again,

each cilium passes through a pellicular ring to join a kinetosome. As in *Paramecium* the kinetodesmas are not single fibers but consists of a series of short, tapering fibrils which overlap in shingle-like fashion. Each fibril arises from a kinetosome. In *Tetrahymena* these kinetodesmal fibrils are so short (1.5 interciliary units in length) that no bundles are formed. The fibrils contain a periodic structure (spiral ?) and are polarized in the anterior direction.

L. G. WELT and R. G. PETERSDORF (Medicine): *The Effect of an Increase in the Oncotic Pressure of the Plasma on the Excretion of Water and Solutes.*

Infusions of 25% albumin were administered to normal subjects in a steady state of physiologic diabetes insipidus and to patients with diabetes insipidus. The rate of infusion of albumin was rapid in 4 normals and in the patients with diabetes insipidus, and was slow in 4 other normals. These infusions promoted an antidiuresis, antisaluresis, diminished rate of excretion of urea, augmented rate of excretion of potassium, and no significant change in creatinine clearance. The antidiuresis, but not the antisaluresis, was more intense with the rapid administration of albumin in normal subjects but not in the patients with diabetes insipidus.

Since the antidiureses (1) were unaccompanied by decreases in filtration rate, (2) occurred in patients with diabetes insipidus, and (3) were always associated with an antisaluresis, it is concluded that the antidiureses were independent of the secretion of the antidiuretic hormone and were probably a passive consequence of increased reabsorption of salt, presumably in the proximal tubule. The fact that the rapid infusion of albumin provoked a more intense antidiuresis only in normals and was unassociated with a greater antisaluresis suggests that this additional antidiuresis may have been due to the secretion of antidiuretic hormone.

503RD MEETING, MARCH 10, 1953

CARL E. ANDERSON (Biological Chemistry) and M. C. WOODS (Biology Div., Oak Ridge National Laboratory): *Radiation Hemorrhage and Spleen Homogenates.*

The protective effect of spleen shielding, non-irradiated mouse spleen transplants, and the intraperitoneal injection of mouse spleen homogenates to mice subjected to large doses of whole body x-irradiation have been reported (Jacobson, 1951, Jour. Lab. Clin. Med. **35:** 746; Cole, 1952, Proc. Soc. Exper. Biol. and Med. **80:** 112). Lorenz on the other hand (ANL-4625, April 1951, pp. 14–20) found that the injection of adult mouse spleen brei after 900 r of exposure failed to protect LA_{fl} mice. Recently Cronkite and Brecker (1952, Ann. Rev. Med **3:** 193) and Woods (ORNL-1297, May 1952) have reported that transfusions of whole platelets into irradiated dogs and rats diminished the post-irradiation hemorrhage. In view of these two lines of investigation it appeared reasonable to believe that the protective effect may be exerted through a stimulation of platelet production.

To test this hypothesis 32 Wistar rats equally divided regarding sex and weighing approx. 250 g. were divided into 4 groups. Each animal received intraperitoneally a sterile solution of non-irradiated rat spleen homogenate (equivalent to 2 rat spleens) immediately after exposure to 750 r whole body x-irradiation except two groups which received an additional injection on the 5th day after exposure and the control group which received an equivalent volume of physiological saline only. The radiation factors were: 250 KVP; 30 ma; filter 3 ml Al.; STD 93 cm.; dosage rate 74 r per minute as measured with a Victoreen 100 r-meter placed in air at the position of the rats. All animals were weighed daily and platelet counts were made on each animal prior to x-irradiation and on the 4th, 8th, and 12th day. The experiment was terminated on the 12th day because of the small number of surviving animals. Under the conditions of this experiment adult rat spleen homogenate failed to protect fats against thrombocytopenia and rapid weight loss. Autopsies performed consistently presented a picture of acute radiation death and severe hemorrhage.

JOHN E. LARSH, JR. AND GEORGE R. RACE (Parasitology): *A Histopathologic Study of the Anterior Small Intestine of Immunized and Non-immunized Mice Infected with* Trichinella spiralis.

The present study was suggested by a recent report that in old mice (5.4–6.1 months) the defensive mechanisms bringing about expulsion of adult worms at reinfection operated only in the proximal half of the small intestine (Larsh, *et al.*, Jour. Elisha Mitch. Sci. Soc. **68:** 1–11).

Based on the previous findings, a similar experiment for the purpose of histopathologic study was performed. Certain of the immunized and control mice were necropsied at intervals from 12 hours to 14 days post-infection. The remainder of the mice were necropsied seven days post-infection. The adult worm counts showed that the immunized mice had developed the usual degree of acquired resistance; and the serologic findings were similar to those reported previously for our mice.

In the immunized mice, a mild inflammatory reaction involving all parts of the mucosa and submucosa was noted as early as 12 hours post-infection. Thereafter, the reaction became acute, reaching a zenith at four days. The predominant cell was the polymorphonuclear leukocyte. As the reaction subsided, the inflammatory infiltrate became mixed mononuclear in type (plasmacytes, lymphocytes, and macrophages).

In the non-immunized controls, the difference in the cellular response from that above was chiefly one of time and severity. The inflammatory reaction developed much more slowly, reaching a peak at about ten days.

In both groups of mice, the peak of the cellular reaction occurred shortly before a sudden loss of worms was noted in comparable groups in the earlier study. These results seem to indicate that cellular mechanisms are involved in this resistance. Evidence from other studies in our mice strongly suggest that such mechanisms come into play after the primary action(s) of antibodies.

504TH MEETING, APRIL 14, 1953

M. S. DAVIS (Astronomy): *Radio Astronomy.*

In the spring of 1951 a strong radiation of 21-cm. wavelength was discovered, and found to be caused by forbidden transitions between the two hyperfine levels of the ground state of hydrogen. This line in the radio region of the electromagnetic spectrum exhibits Doppler shifts because of the relative motions of the radiating gas and the sun. Differential rotation of the galaxy enables the radio astronomer to study the distribution of hydrogen by means of the Doppler shifts. The abundance of hydrogen and general structure of the galaxy are both confirmed.

A description of the most recent radio telescopes was given.

G. P. MANIRE (Bacteriology): *Toxins Associated with Psittacosis Virus.*

The adoption of a resolution concerning the dismissal of Dr. Allen Astin, Director of the National Bureau of Standards, was moved by Dr. Walter Hartung and seconded by Dr. William Straughn; the motion, which was unanimously approved, contained the following resolutions:

(1) That the Elisha Mitchell Scientific Society at its 504th regular meeting voice its objections to the manner in which Secretary Weeks has summarily dismissed the Director of the National Bureau of Standards, since such methods are an affront to science and scientists.

(2) That the Elisha Mitchell Society deplores the intimation by Secretary Weeks that the "play of the market place" should color the objective reports emanating from the National Bureau of Standards, for if such a policy should ever be adopted, the value and integrity of the Bureau would be completely destroyed.

(3) That the Elisha Mitchell Society call upon the Secretary of Commerce, and if necessary ask Congress to intervene, to have an impartial and unbiased committee, composed of experts, examine at the earliest possible date into the merits of AD-X2 and related substances, rendering a full report and interpretation of their findings to interested scientific bodies and to the public. This is essential and necessary for the following reasons:

a) If the implications of the Secretary of Commerce are true that the Bureau of Standards is guilty of issuing prejudicial and biased reports, and, therefore, is no longer the impartial fact-finding body it is designed and we still believe it to be, then the sooner the matters are aired and corrected, the better.

b) If the accusations of the Secretary of Commerce are without foundation, the Bureau deserves to have its name cleared promptly so that the public may continue its reliance on the Bureau and its reports with renewed confidence.

505TH MEETING, MAY 12, 1953

E. K. GOLDIE-SMITH (Botany): *Studies in the Plasmodiophoraceae.* (Abstract printed in the Proceedings of the N. C. Adademy of Science, in the current issue of the Journal.)

At the beginning of the meeting Dr. Straughn presented a certificate and a check for $50.00 to Miss E. K. Goldie-Smith, as winner of the William Chambers Coker Award in Science for the year 1952–3.

The treasurer's report was read, and the Auditing Committee (L. L. Garner and J. C. Morrow), reported the books in order.

The Nominating Committee (J. H. Ferguson, V. A. Greulach, and H. D. Crockford, Chairman) presented the following slate of nominees for the year 1953–54:

President—J. C. Andrews
Vice-President—R. L. Ingram
Secretary-Treasurer—J. C. Morrow
Associate Editors of the Journal—G. R. MacCarthy, W. C. George

The slate was unanimously elected.

J. C. MORROW, *Sec.-Treas.*

A MATHEMATICAL EXAMINATION OF SPIRALED COMPOUND CURVES*

By T. F. Hickerson

Kenan Professor of Applied Mathematics, Emeritus, University of North Carolina
Chapel Hill, North Carolina

Synopsis

In considering spiraled compound curves (see Figs. 1 and 2), one is confronted with the question: What are the limits of spiral length and total change in curvature beyond which desirable accuracy is not attainable. The reason for this doubt arises from the usual assumption—based partly on intuition—that the total radial separation of the two branches of the compound curve depends on the nominal "spiral angle", a quantity analogous to the central angle of a spiral joining a straight line with a circular curve.

It will be shown that the conventional procedure agrees closely with rigorous theory for the ordinary range of values. This is to be expected since a transition spiral is a curve of uniformly changing curvature, hence it should diverge in angle and offset, for a given distance, at about the same rate from the osculating circle as from the initial tangent.

Introduction

Referring to Figs. 1 and 2, let D_1 and R_1 equal, respectively, the degree of curve and the radius of the flatter curve subtending central angle Δ_1; while D_2 and R_2 apply to the sharper curve subtending angle Δ_2; and let the total central angle $=\Delta(=\Delta_1 + \Delta_2)$. Also,

$l = AP$ = length of any spiral arc;
$l_s = AB_1$ = total length of spiral;
β = central angle of arc AP [$\beta = \Delta$, for arc AB_1];
D = degree of curve of the spiral at any point (as P);
θ_s = nominal spiral angle;
c = chord AB_1 = spiral long chord;
p = total radial shift at C (the P.C.C.) [$p = CC_1 = OO_2 = BB_1$];
x, y = coordinates of any point P of the spiral (see (*b*) of Figs. 1 and 2);
$x_1 = AG$, $y_1 = GB_1$;
T_1 and T_2 = tangent distances AV and VB_1, respectively, where T_1 is the long tangent and T_2 is the short tangent.

Case I: *Sharper branch shifted radially inward at C, Fig. 1.*

Since it is the function of the transition spiral to change the degree of curve uniformly as the arc distance from A (the C.S.) to any point P, we have

$$D = D_1 + l/l_s\,(D_2 - D_1). \qquad \text{(a)}$$

* Presented at the Mathematics Section of the 50th Annual Meeting of the N. C. Academy of Science at Raleigh, May 8–9, 1953.

From the differential sector at point P (see (b) of Fig. 1), we have

$$d\beta = \frac{dl}{R} = \frac{D}{100}\,dl, \tag{b}$$

where R (feet) $= \frac{100}{D}$, D being measured in radians.

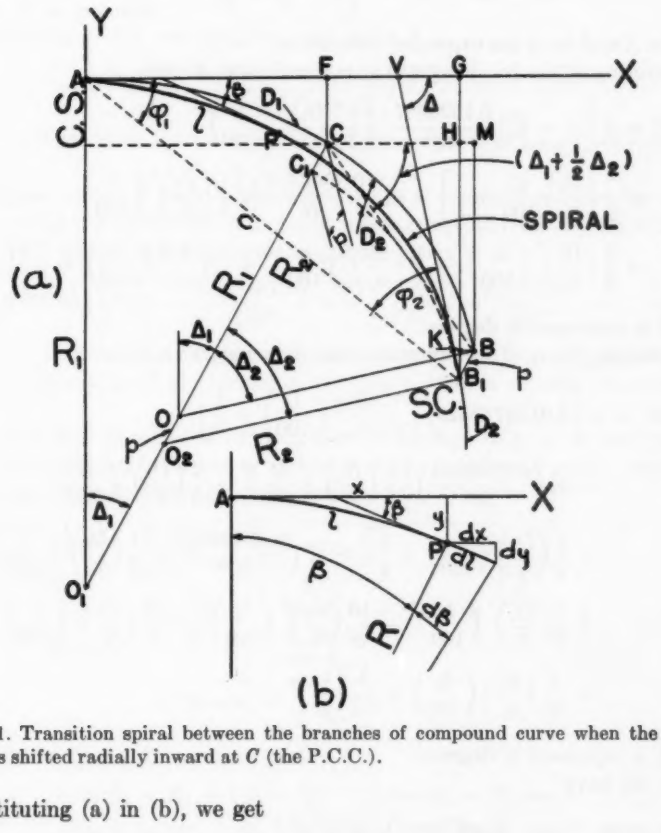

FIG. 1. Transition spiral between the branches of compound curve when the sharper branch is shifted radially inward at C (the P.C.C.).

Substituting (a) in (b), we get

$$d\beta = \frac{1}{100}\,[D_1 + l/l_s(D_2 - D_1)]\,dl. \tag{c}$$

Integrating, we get

$$\beta = \frac{1}{100}\left[D_1 l + \left(\frac{D_2 - D_1}{l_s}\right)\frac{l^2}{2}\right] = \frac{D_1 l}{100} + (l/l_s)^2\theta_s, \tag{d}$$

where $\theta_s = \frac{ls}{200}\,(D_2 - D_1)$ = nominal spiral angle.

Noting that the coordinate axes coincide with AG and O_1A respectively, we have (see Fig. 1b),

$$dx = dl \cos \beta = dl \left[1 - \frac{\beta^2}{2!} + \frac{\beta^4}{4!} - \cdots \right], \tag{e}$$

and

$$dy = dl \sin \beta = dl \left[\beta - \frac{\beta^3}{3!} + \frac{\beta^5}{5!} - \cdots \right], \tag{f}$$

where $\cos \beta$ and $\sin \beta$ are expanded into series.

Substituting (d) in (e), integrating, and reducing, we get

$$\begin{aligned} x_1 = AG = l_s \Bigg[1 &- \theta_s^2 \left(\frac{0.1523087}{10^3} \right) \left[\frac{1}{3} \left(\frac{D_1}{\theta_s} \right)^2 \left(\frac{l_s}{100} \right)^2 \right. \\ &+ \frac{1}{2} \left(\frac{D_1}{\theta_s} \right) \frac{l_s}{100} + \frac{1}{5} \Bigg] + \theta_s^4 \left(\frac{0.3866324}{10^8} \right) \left[\frac{1}{5} \left(\frac{D_1}{\theta_s} \right)^4 \left(\frac{l_s}{100} \right)^4 \right. \\ &+ \frac{2}{3} \left(\frac{D_1}{\theta_s} \right)^3 \left(\frac{l_s}{100} \right)^3 + \frac{6}{7} \left(\frac{D_1}{\theta_s} \right)^2 \left(\frac{l_s}{100} \right)^2 + \frac{1}{2} \left(\frac{D_1}{\theta_s} \right) \left(\frac{l_s}{100} \right) + \frac{1}{9} \Bigg] \Bigg], \end{aligned} \tag{1}$$

where θ_s is expressed in degrees.

Substituting (d) in (f), integrating, and reducing, we get

$$\begin{aligned} y_1 = GB_1 = l_s \Bigg[&\theta_s (0.01745329) \left[\frac{1}{2} \left(\frac{D_1}{\theta_s} \right) \left(\frac{l_s}{100} \right) + \frac{1}{3} \right] \\ &- \theta_s^3 \left(\frac{0.8860964}{10^6} \right) \left[\frac{1}{4} \left(\frac{D_1}{\theta_s} \right)^3 \left(\frac{l_s}{100} \right)^3 + \frac{3}{5} \left(\frac{D_1}{\theta_s} \right)^2 \left(\frac{l_s}{100} \right)^2 \right. \\ &+ \frac{1}{2} \left(\frac{D_1}{\theta_s} \right) \left(\frac{l_s}{100} \right) + \frac{1}{7} \Bigg] + \theta_s^5 \left(\frac{0.13496017}{10^{10}} \right) \left[\frac{1}{6} \left(\frac{D_1}{\theta_s} \right)^5 \left(\frac{l_s}{100} \right)^5 \right. \\ &+ \frac{5}{7} \left(\frac{D_1}{\theta_s} \right)^4 \left(\frac{l_s}{100} \right)^4 + \frac{10}{8} \left(\frac{D_1}{\theta_s} \right)^3 \left(\frac{l_s}{100} \right)^3 + \frac{10}{9} \left(\frac{D_1}{\theta_s} \right)^2 \left(\frac{l_s}{100} \right)^2 \\ &+ \frac{5}{10} \left(\frac{D_1}{\theta_s} \right) \left(\frac{l_s}{100} \right) + \frac{1}{11} \Bigg] \Bigg], \end{aligned} \tag{2}$$

where θ_s is expressed in degrees.

Next, we have

c = spiral "long chord" = $\sqrt{x_1^2 + y_1^2}$; (3)

Φ_1 = total deflection angle from A to B_1 = arc tan $\frac{y_1}{x_1}$; (4)

$\Phi_2 = \Delta - \Phi_1$ (5)

$T_1 = AV$ = long tangent = $AG - VG = x_1 - y_1 \cot \Delta$; (6)

$T_2 = VB_1$ = short tangent = $\frac{GB_1}{\sin \Delta} = \frac{y_1}{\sin \Delta}$; (7)

In Fig. 1a, let verticals through B_1 and B intersect a horizontal line through C at H and M respectively. Also, let a horizontal line through B intersect the vertical GB_1 at K.

Then

$$y_1 = GB_1 = GH + HK + KB_1 ; \tag{g}$$

where $GH = FC = R_1 \text{ vers } \Delta_1$,

$HK = MB = BC \sin BCM = 2R_2(\sin \tfrac{1}{2}\Delta_2)(\sin (\Delta_1 + \tfrac{1}{2}\Delta_2))$, and $KB_1 = BB_1 \cos \Delta_1 = p \cos \Delta_1$.

Substituting in (h), and reducing, we get

$$p = \frac{y_1 - R_1 \text{ vers } \Delta_1 - 2R_2(\sin \tfrac{1}{2}\Delta_2)(\sin (\Delta_1 + \tfrac{1}{2}\Delta_2))}{\cos \Delta_1} . \tag{8}$$

Eqs. (1–8) are basic formulas giving the various parts of a spiraled compound curve.

An independent, but slightly approximate, set of formulas will now be derived on the basis of the radial shift p found in tables compiled from Eq. (h) when the "equivalent" spiral angle and spiral length are given.

$$p = l_s\left[0.00145444410\theta_s - \frac{0.1582315\theta_s^3}{(10)^7} + \frac{0.1022426\theta_s^5}{(10)^{12}} - \frac{0.40785\theta_s^7}{(10)^{18}} + \cdots\right], \tag{h}$$

where θ_s is expressed in degrees, and this p has special reference to the spiral which provides a gradual change in curvature from a *straight* to a circular path.

With O_1A as zero azimuth (north), treat $AO_1O_2B_1A$ (Fig. 1) as a closed traverse. Accordingly, $y = d \cos A$ and $x = d \sin A$, where d and A represent distance and azimuth respectively, as indicated below.

Point	Azimuth	Distance	y	x
A (C.S.)	180°	R_1	$-R_1$	0
O_1	Δ_1	O_1O_2	$(R_1 - R_2 - p) \text{ Cos } \Delta_1$	$(R_1 - R_2 - p) \sin \Delta_1$
O_2	Δ	R_2	$R_2 \cos \Delta$	$R_2 \sin \Delta$
B_1	$270° + \Phi_1$	c	$c \sin \Phi_1$	$-c \cos \Phi_1$
		Sum =	0	0

From $\Sigma y = 0$ and $\Sigma x = 0$, we get

$$c \sin \Phi_1 = R_1 - (R_1 - R_2 - p) \cos \Delta_1 - R_2 \cos \Delta \tag{i}$$

$$c \cos \Phi_1 = (R_1 - R_2 - p) \sin \Delta_1 + R_2 \sin \Delta \tag{j}$$

Let

$$N_1 = R_1 - (R_1 - R_2 - p) \cos \Delta_1 - R_2 \cos \Delta. \tag{k}$$

$$B_1 = (R_1 - R_2 - p) \sin \Delta_1 + R_2 \sin \Delta. \tag{l}$$

Then on dividing (i) by (j), we get $\tan \Phi_1 = \dfrac{N_1}{B_1}$, from which

$$\Phi_1 = \text{arc tan } \frac{N_1}{B_1} \tag{9}$$

This value of Φ_1 should agree closely with the spiral deflection formula:

$$\frac{l_s D_1}{200} + \frac{\theta_s}{3}.$$

From (j), we get

$$c = \frac{B_1}{\cos \Phi_1}. \tag{10}$$

Applying the law of sines (see Fig. 1a), we have

$$T_2 = \frac{c}{\sin \Delta} \times \sin \phi_1 = \frac{N_1}{\sin \Delta}. \tag{11}$$

Since $T_1 + VG = T_1 + T_2 \cos \Delta = c \cos \Phi_1$, we get

$$T_1 = B_1 - T_2 \cos \Delta = B_1 - N_1 \cot \Delta. \tag{12}$$

As an independent check,

$$c = T_1 \cos \Phi_1 + T_2 \cos \Phi_2. \tag{m}$$

Example 1. Given $D_1 = 6°$, $D_2 = 10°$, $l_s = 300$ ft. Required: The parts of a transition spiral (Fig. 1) by both the exact and the conventional methods.

SOLUTION: The nominal spiral angle $= \theta_s = \frac{300}{200}(10 - 6) = 6°$; $\frac{\theta_s}{D_1} = 1$. Applying Eqs. 1 and 2, we get $x_1 = 292.33$ ft., $y_1 = 56.808$ ft.; from which (by Eqs. 2–8): $c = 297.80$ ft., $\Phi_1 = 10°59'49''$, $\Phi_2 = 13°00'11''$, $T_1 = 164.74$ ft., $T_2 = 139.67$ ft., and $p = 2.603$ ft.

With $\theta_s = 6°$ and $l_s = 300$ ft., $p = 300 \times 0.00872 = 2.616$ ft., in which 0.00872 is a unit value of p (found in tables) as if the spiral joined a straight line with a circular curve. Accordingly, by Eqs. 9–12, $\Phi_1 = 10°59'51''$, $\Phi_2 = 13°00'19''$, $c = 297.86$ ft., $T_2 = 139.70$ ft., and $T_1 = 164.76$ ft.

Example 2. Given $D_1 = 10°$, $D_2 = 20°$, $l_s = 200$ ft.

Required: The parts of a transition spiral (Fig. 1) by both the exact and the conventional method.

SOLUTION: The nominal spiral angle $= \frac{200}{200}(20 - 10) = 10°$; $\theta_s/D_1 = 1$.

Applying Eqs. 1 and 2, we get $x_1 = 192.38$ ft., $y_1 = 45.569$ ft.; from which (Eqs. 2–9), $c = 197.71$ ft., $\Phi_1 = 13°19'32''$, $\Phi_2 = 16°40'28''$, $T_1 = 113.46$ ft., $T_2 = 91.14$ ft., and $p = 2.879$ ft.

With $\theta_s = 10°$ and $l_s = 200$ ft., $p = 200 \times 0.01453 = 2.906$ ft., in which 0.01453 is a unit value of p (found in tables) as if the spiral joined a straight line with a circular curve. Accordingly, by Eqs. 9–12, $\Phi_1 = 13°19'36''$, $\Phi_2 = 16°40'24''$, $c = 197.81$ ft., $T_2 = 91.19$ ft., and $T_1 = 113.51$ ft.

CASE II: *Flatter branch shifted radially outward at C, Fig. 2.*

In this case, the degree of curve decreases uniformly as the arc distance from A (the C.S.), hence

$$D = D_2 - l/l_s(D_2 - D_1). \tag{n}$$

Substituting (n) in (b), integrating, and reducing, we get

$$\beta = \frac{D_2 l}{100} - (l/l_s)^2 \theta_s. \tag{o}$$

where $\theta_s = \frac{l_s}{200}(D_2 - D_1)$, as in Case I.

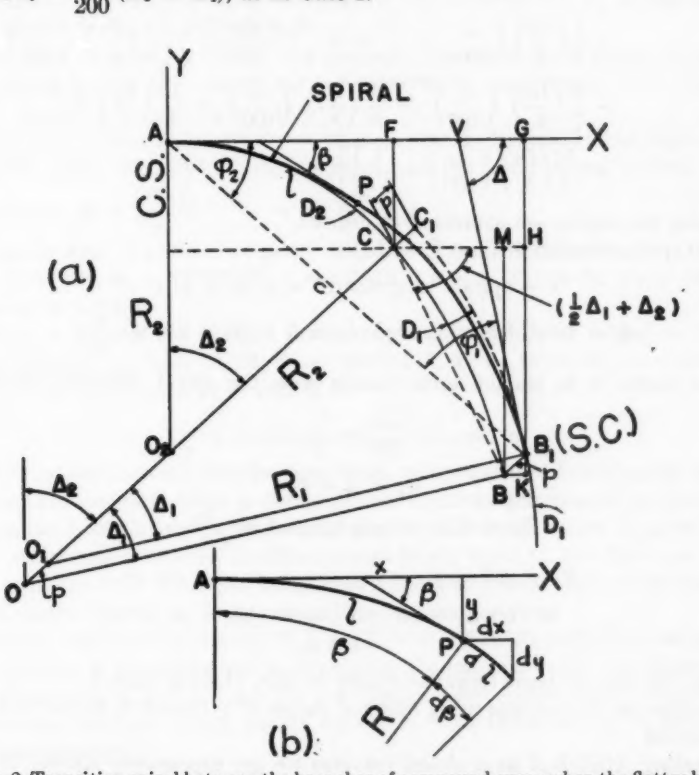

FIG. 2. Transition spiral between the branches of compound curve when the flatter branch is shifted radially outward at C (the P.C.C.).

Substituting, in turn, (o) in (e) and (f), integrating, and reducing, we get

$$x_1 = AG = l_s\left[1 - \theta_s^2\left(\frac{0.1523087}{10^3}\right)\left[\frac{1}{3}\left(\frac{D_2}{\theta_s}\right)^2\left(\frac{l_s}{100}\right)^2 - \frac{1}{2}\left(\frac{D_2}{\theta_s}\right)\left(\frac{l_s}{100}\right) + \frac{1}{5}\right] + \theta_s^4\left(\frac{0.3866324}{10^8}\right)\left[\frac{1}{5}\left(\frac{D_2}{\theta_s}\right)^4\left(\frac{l_s}{100}\right)^4 - \frac{2}{3}\left(\frac{D_2}{\theta_s}\right)^3\left(\frac{l_s}{100}\right)^3 + \frac{6}{7}\left(\frac{D_2}{\theta_s}\right)^2\left(\frac{l_s}{100}\right)^2 - \left[\frac{1}{2}\left(\frac{D_2}{\theta_s}\right)\left(\frac{l_s}{100}\right) + \frac{1}{9}\right]\right]\right]; \tag{13}$$

and

$$y_1 = GB_1 = l_s\left[\theta_s(0.01745329)\,\frac{1}{2}\left(\frac{D_2}{\theta_s}\right)\left(\frac{l_s}{100}\right) - \frac{1}{3}\right] - \theta_s^2\left(\frac{0.8860964}{10^6}\right)\left[\frac{1}{4}\left(\frac{D_2}{\theta_s}\right)^3\left(\frac{l_s}{100}\right)^3 - \frac{3}{5}\left(\frac{D_2}{\theta_s}\right)^2\left(\frac{l_s}{100}\right)^2 + \frac{1}{2}\left(\frac{D_2}{\theta_s}\right)\left(\frac{l_s}{100}\right) - \frac{1}{7}\right] + \theta_s^5\left(\frac{0.13496017}{10^{10}}\right)\left[\frac{1}{6}\left(\frac{D_2}{\theta_s}\right)^5\left(\frac{l_s}{100}\right)^5 - \frac{5}{7}\left(\frac{D_2}{\theta_s}\right)^4\left(\frac{l_s}{100}\right)^4 + \frac{10}{8}\left(\frac{D_2}{\theta_s}\right)^3\left(\frac{l_s}{100}\right)^3 - \frac{10}{9}\left(\frac{D_2}{\theta_s}\right)^2\left(\frac{l_s}{100}\right)^2 + \frac{5}{10}\left(\frac{D_2}{\theta_s}\right)\left(\frac{l_s}{100}\right) - \frac{1}{11}\right]\Bigg]. \tag{14}$$

in which the angles are expressed in degrees.

Next, proceeding as in Case I, we have

$$c = \text{spiral "long chord"} = \sqrt{x_1^2 + y_1^2}\,; \tag{15}$$

$$\Phi_2 = \text{total deflection angle from } A \text{ to } B_1 = \text{arc tan}\,\frac{y_1}{x_1}\,; \tag{16}$$

This value of Φ_2 should agree closely with the spiral deflection formula:

$$\frac{l_s D_2}{200} - \frac{\theta_s}{3}.$$

$$\Phi_1 = \Delta - \Phi_2\,; \tag{17}$$

$$T_1 = VB_1 = \text{long tangent} = \frac{y_1}{\sin\Delta}; \tag{18}$$

$$T_2 = AV = \text{short tangent} = x_1 - y_1\cot\Delta; \tag{19}$$

$$p = \frac{R_2\,\text{vers}\,\Delta_2 + 2R_1\sin\tfrac{1}{2}\Delta_1\sin(\tfrac{1}{2}\Delta_1 + \Delta_2) - y_1}{\cos\Delta_2}. \tag{20}$$

Eqs. (13–20) are basic formulas similar to Eqs. (1–8) of Case I.

Another set of formulas using nominal values of p (found in tables) will now be derived.

Treating $AO_2O_1B_1A$ as a closed traverse we get expressions similar to Eqs. (9–12) in Case I, as follows:

$$N_2 = R_2 + (R_1 - R_2 - p)\cos\Delta_2 - R_1\cos\Delta; \tag{p}$$

$$B_2 = R_1\sin\Delta - (R_1 - R_2 - p)\sin\Delta_2\,; \tag{q}$$

$$\Phi_2 = \text{total deflection angle from } A \text{ to } B_1 = \text{arc tan}\,\frac{N_2}{B_2}\,; \tag{21}$$

$$\Phi_1 = \Delta - \Phi_2\,; \tag{22}$$

$$c = \frac{B_2}{\cos\Phi_2}\,; \tag{23}$$

$$T_1 = \frac{N_2}{\sin\Delta}\,; \tag{24}$$

$$T_2 = B_2 - T_1\cos\Delta = B_2 - N_2\cot\Delta. \tag{25}$$

Example 3. Given $D_1 = 6°$, $D_2 = 10°$, $l_s = 300$ ft. Required: The parts of a transition spiral (Fig. 2) by both the exact and the conventional method.

SOLUTION: $\theta_s = \frac{300}{200}(10 - 6) = 6°$; $\theta_s/D_2 = \frac{3}{5}$.

Applying Eqs. 13 and 14, we get $x_1 = 290.17$ ft., $y_1 = 67.006$ ft.; from which (Eqs. 15–20), $c = 297.80$ ft., $\Phi_2 = 13°00'10''$, $\Phi_1 = 10°59'50''$, $T_1 = 164.74$ ft., $T_2 = 139.67$ ft., and $p = 2.626$ ft.

With $\theta_s = 6°$ and $l_s = 300$ ft., the nominal value of p (from tables) = 2.616 ft. Accordingly, by Eqs. 21–25, $\Phi_2 = 13°00'09''$, $\Phi_1 = 10°59'51''$, $c = 297.86$ ft., $T_1 = 164.76$ ft., and $T_2 = 139.70$ ft.

Example 4. Given $D_1 = 4°$, $D_2 = 6°$, $l_s = 600$ ft. Required: The parts of a transition spiral (Fig. 2) by both the exact and the conventional method.

SOLUTION: $\theta_s = \frac{600}{200}(6 - 4) = 6°$; $\theta_s/D_2 = 1$.

Applying Eqs. 13 and 14, we get $x_1 = 570.16$ ft., $y_1 = 163.541$ ft.; from which $\Phi_1 = 13°59'44''$, $\Phi_2 = 16°00'16''$, $c = 593.15$ ft., $T_1 = 327.08$ ft., $T_2 = .286.90$ ft., and $p = 4.995$ ft.

With $\theta_s = 6°$ and $l_s = 600$ ft., the nominal value of p (from tables) = 5.232 ft. Accordingly, by Eqs. 21–25, $\Phi_2 = 16°00'13''$, $\Phi_1 = 13°59'47''$, $c = 593.26$ ft., $T_1 = 327.12$ ft., and $T_2 = 286.98$ ft.

COMMENTS AND CONCLUSIONS

The four illustrative examples—two from each case—are intentionally more extreme than typical in order to obtain outside limits for purposes of comparison.

Examples 1 and 3 are identical except for the calculated values of x_1 and y_1, which are unequal because of different coordinate axes. In the first case, the x-axis coincides with the initial tangent to the flatter curve, while in the second case, it coincides with the initial tangent to the sharper curve.

Formulas 1–8 (Case I) and 13–20 (Case II) are too cumbersome for use in the field but basic in compiling tables. Except for the nominal value of p, Formulas 9–12 (Case I) and 21–25 (Case II) are theoretically correct and in line with conventional methods giving results consistent with the accuracy of ordinary field measurements.

NOTE ON A NON-SELF-ADJOINT DIFFERENTIAL SYSTEM OF THE SECOND ORDER

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The present note gives further consideration to the differential system treated in a paper by A. K. Hinds and W. M. Whyburn[1]. In particular, it states an additional hypothesis needed for lemma 5 of the paper cited and indicates how a modified form of this lemma can be proved without use of all the given hypotheses. Terminology, notation, and conventions are those used in the paper cited.

Theorem. Under[2] hypotheses i)—v) together with either

(a) $\theta(\mu_n) \geqq 1$ and $F(x, \mu_n)$ non-decreasing on X,

or

(b) $\theta(\mu_n) \geqq F(a, \mu_n)/F(b, \mu_n)$ and $F(x, \mu_n)$ non-increasing on X,

where $F(x, \lambda) = -G(x, \lambda)/K(x, \lambda)$, $\theta(\lambda) = [\alpha_b^2 + \beta_b^2]^2[\delta_a^2 + F_a\gamma_a^2]/\Delta(\lambda)^2[\beta_b^2 + F_b\alpha_b^2]$, $\Delta(\lambda) = \alpha_a\delta_a - \beta_a\gamma_a$, the quantity $H(\lambda) = \sin(v_b - \tau_b)/[\sin(v_b - \tau_b) + \sin(v_a - \tau_a)]$ takes on every value between zero and one-half between each two numbers, λ_n, μ_n, for which $v(b, \lambda_n) - \tau(b, \lambda_n) = (n - \frac{1}{2})\pi$, $v(b, \mu_n) - \tau(b, \mu_n) = (n + \frac{1}{2})\pi$ (n being a non-negative integer which is even or odd according as $v_a - \tau_a$ is positive or negative). In particular, the equation $H(\lambda) = U_a/(U_a + U_b)$ is satisfied for at least one value of λ between λ_n and μ_n. Furthermore, if $v(b, \rho_n) - \tau(b, \rho_n) = (n + 3/2)\pi$, there is also a characteristic number of system (1), (2) between μ_n and ρ_n.

Proof. From the continuity in λ of $v_b - \tau_b$, there is at least one value of λ between λ_n and μ_n for which this takes the value $n\pi$. For such values, $H(\lambda)$ vanishes and the set of zeros of $H(\lambda)$ between λ_n and μ_n is closed. Let η_n be such that $H(\eta_n) = 0$ while $H(\lambda) \neq 0$ between μ_n and η_n. Then $H(\mu_n) = 1/[1 + |\sin(v_a - \tau_a)|]$ and hence $H(\mu_n) \geqq \frac{1}{2}$. Furthermore, $\sin(v_b - \tau_b)$ and $\sin(v_a - \tau_a)$ have the same sign, hence the denominator of $H(\lambda)$ does not vanish, between η_n and μ_n. $H(\lambda)$ is therefore continuous and takes on every value between zero and $1/[1 + |\sin(v_a - \tau_a)|]$ for at least one value of λ between η_n and μ_n. It remains to show that $U_a/(U_a + U_b) = 1/(1 + U_b/U_a) \leqq 1/[1 + |\sin(v_a - \tau_a)|]$, or $U_b^2 \geqq U_a^2[\sin^2(v_a - \tau_a)]$ for $\lambda = \mu_n$. This requires that

$$\text{(I)} \quad I = \int_a^b (K + G)\sin 2v\, dt \geqq \log[\Delta(\lambda)^2/(\alpha_b^2 + \beta_b^2)(\gamma_a^2 + \delta_a^2)], \quad \text{for } \lambda \neq \mu_n.$$

[1] A. K. Hinds and W. M. Whyburn, Jour. Elisha Mitchell Sci. Soc. **68** (1952): 32–43. Hereafter, this paper will be referred to as HW.

[2] See HW, pp. 33–34.

Now

$$I = \int_a^b [(K + G) \sin 2v/(K \cos^2 v - G \sin^2 v)]v' \, dt$$

$$= \int_{v_a}^{v_b} [(1 - F)/(\cos^2 v + F \sin^2 v)] \sin 2v \, dv$$

$$= \int_{\sin^2 v_a}^{\sin^2 v_b} (1 - F) \, dw/[1 - (1 - F)w], \qquad w = \sin^2 v,$$

$$= \int_{\cos^2 v_a}^{\cos^2 v_b} (1 - 1/F) \, dz/[1 - (1 - 1/F)z], \qquad z = \cos^2 v.$$

Hence

$$I = \int_{(1-F_a)\sin^2 v_a}^{(1-F_b)\sin^2 v_b} d[(1 - F)w]/[1 - (1 - F)w] + \int_{F_a}^{F_b} w \, dF/[1 - (1 - F)w]$$

$$\geqq \log [1 - (1 - F_a) \sin^2 v_a]/[1 - (1 - F_b) \sin^2 v_b],$$

in the case hypothesis (a) is met so that W, F, dF and the second integral are non-negative. For $\lambda = \mu_n$, $\sin^2 v_a = \gamma_a^2/[\gamma_a^2 + \delta_a^2]$, $\sin^2 v_b = \alpha_b^2/[\alpha_b^2 + \beta_b^2]$ and substitution of these values into the foregoing inequality yields formula (I) when hypothesis (a) is taken into account.

In case hypothesis (b) holds, the integral in Z is used to obtain

$$I \geqq \log [F_a - (F_a - 1) \cos^2 v_a]F_b/F_a[F_b - (F_b - 1) \cos^2 v_b]$$

$$\geqq \log [1 - (1 - F_a) \sin^2 v_a]F_b/F_a[1 - (1 - F_b) \sin^2 v_b].$$

Replacement of $\sin^2 v_a$ and $\sin^2 v_b$ in this inequality and use of hypothesis (b) yields the theorem for this case.

The existence of a characteristic number between μ_n and ρ_n follows from $U(a, \mu_n)/[U(a, \mu_n) + U(b, \mu_n)] \leqq H(\mu_n)$, $H(\rho_n) = 0 < U(a, \rho_n)/[U(a, \rho_n) + U(b, \rho_n)]$, and the continuity of $H(\lambda)$ on the interval between μ_n and ρ_n.

Corollary. Lemma 5 of paper[3] HW, with the range of $H(\lambda)$ set between zero and one-half, follows from the foregoing theorem where hypotheses vi), viii), x), xii) of that lemma are replaced by hypotheses (a) and (b) of the theorem.

Example. The system $y' = \lambda(1 + 3x^2)z$, $z' = -\lambda(1 + 3x^2)\, y$, $\lambda > 0$, together with conditions $y(0, \lambda) = 0$, $z(0, \lambda) = z(1, \lambda) - y(1, \lambda)$ satisfies the hypotheses of the foregoing theorem and those used in paper HW. For this system, $y = A \sin \lambda x(1 + x^2)$, $z = A \cos \lambda x(1 + x^2)$ satisfies the first condition for $A \neq 0$ and $\lambda > 0$. The second boundary condition holds if $\lambda = n\pi$, where $n = 1, 2, 3, \cdots$. These then are the characteristic numbers of the system and the corresponding characteristic solutions are $y = \sin n\pi x(1 + x^2)$, $z = \cos n\pi x(1 + x^2)$.

The foregoing example satisfies both conditions (a) and (b) of the theorem.

[3] *Loc. cit.*, page 38.

In general, these conditions prevent the amplitudes of the solutions from decreasing too rapidly as x increases. Conditions which would insure stability of the solutions for large x through bounding the amplitudes, would be obtained by interchanging the requirements on the monotonic character of $F(x, \lambda)$ between conditions (a) and (b). These changed conditions are also met by the system used in the example and the solutions exhibit the property of stability.

CAROLINA BAYS: ADDITIONAL DATA ON THEIR ORIGIN, AGE AND HISTORY

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On the coastal plain of the southeastern U. S. are local interstream areas of flat, non-draining, peaty uplands which are usually covered with a complex of fire resistant (by regenerative shoot development) shrubs and small trees, including the pond pine (*P. serotina*). On the margins of these peat lands where the soil oxygen is higher for longer periods because of the shorter periods of waterlogging (hydroperiods), are commonly found two kinds of bay trees, the red bay (*Persea Borbonia*) and the sweet bay (*Magnolia virginiana*). A third highly fire resistant (by regeneration) bay, the loblolly bay (*Gordonia lasianthus*), which is distributed widely over the bog areas proper, may also occur with the two just mentioned. This occurence of marginal bay trees observed by the pioneers and probably believed by them to dominate the impenetrable body of these shrub-bogs, is believed to be the basis for the name "bays" given by white men to these areas. So well defined were these evergreen shrub and small tree communities, that the Indian also had a name for them viz. "pocosins".

Based on their physiographic structure, three kinds of bays may be recognized: (1) Branch bays (Wright, 1932) which are found on the poorly drained, broad, flat heads of streams. (2) Estuary bays (Wells, 1946). These are the largest, being five to twenty-five miles wide, and occupy the now relatively elevated flat bottoms of ancient estuaries when the sea level was above its present position. Holly Shelter and Angola Bays are examples. (3) Carolina bays (Melton, 1933). This physiographically non-committal name has come into universal use for the thousands of remarkable, mathematically elliptical shallow basins of restricted size ("a few hundred feet to seven miles"; Prouty, 1952) which dot the six upper terraces of the coastal plain in the two Carolinas. Most of them are filled with peat and densely covered by the characteristic shrub-bog vegetation (*Cyrilla, Zenobia, Lyonia* and about 20 others) and the marginal bay trees. In the judgment of the writer, the name of these bays should be changed to "Meteorite bays" in line with their physiographic origin.

There is evidence (well preserved stumps) that most of these bays or shrub-bogs (all 3 types) were preceded by swamp forests dating back in postglacial time to periods when the rainfall was much greater over the southeastern coastal plain. With the coming of the Indian-made fires these upland swamp forests have been reduced to the shrub complex. Indeed on many, the peat has been destroyed and the herbaceous savanna has taken over, the perennial rhizomes being protected by the mineral soil. The shrub-bog communities dealt with in this paper thus occupy a middle position in the retrogressive fire sere.

The most important feature of the ecological niche occupied by all of the bay communities is the seasonal or long-time fluctuation of the water table; during

rainy summers the water stands at or near the surface, creating a low soil oxygen condition which prevents the invasion of mesic or high soil oxygen plants, while in drier years, due to the upland site, the water table falls two to six or more feet, thereby eliminating any juvenile plants of the marsh and aquatic type. The herbaceous species of the coastal plain mineral soil savannas are isolated as a distinctive complex by the same seasonal fluctuation.

ECOLOGICAL EVIDENCE FOR METEORITE ORIGIN OF CAROLINA BAY BASINS

The concept was developed that if the Carolina bay basins were formed by extremely slow slumping through solute removal (Johnson, 1944), the only plants which would survive in these at first very shallow depressions would be woody ones, for, under the condition of low fire prevailing in the pre-Indian period, only the dominating woody plants of the swamp gum forest or shrub-bog type could survive the seasonal low water table extreme. Aquatic (water-lily) types cannot invade and persist in such very shallow upland depressions. They never do so today. On a solution basis of origin, the peat from base to surface, irrespective of that lost by fire, should disclose pollen dominated by that of woody species with no occurrence of the pollen of aquatics, which never is abundant enough or in a position to be carried far by wind. Thus it became clear that the presence or absence of aquatic plant pollen in the bottom peat constituted critical evidence in relation to the manner of Carolina bay formation. Five typical bays in Brunswick County, N. C. in the vicinity of Southport and one in Pender County were checked and in every one water lily pollen, either the large grains of *Nuphar* or the smaller ones of *Nymphaea*, were found. *Utricularia* was also noted in all of them.

The location of three of these bays is shown in figures 1 and 2. The margin of the Suffolk scarp made by the Pamlico sea is indicated in the diagram (Fig. 2) by the dotted line. The other two Brunswick County bays were about eight miles north of the three just mentioned. The Pender County bay is located on the north side of the great Holly Shelter estuary bay.

All of the five bays checked showed evidence of fire but in no instance was this evidence (bits of charcoal) present in the basal layer. Where fire had been present the particles of charcoal were so numerous as to give the safranin stained slide a characteristic dark appearance in contrast to the clearer color of the non-charcoal bearing slides made from the bottom or undisturbed peats. The depth to which the peat had been burned below the present surface varied in the Brunswick County shallow bays from one to two feet, a fact indicative of a fluctuating water table.

It may thus be stated categorically that these shallow upland Carolina bays with their seasonal fluctuating water tables could never have had open water aquatics developed in them as required by the solution theory (Johnson, 1944) for under the century long extremely slow process of depression, woody peat formation would have filled them from the beginning. Only fire could have later lowered their surfaces below that of the ground water in wet seasons, resulting in pond formation. However, since in the basal peats reported here the critical

evidence for fire was lacking, the open water condition indicated by the undisturbed basal pollen may be properly interpreted as positive evidence for the sudden or catastrophic formation of the depressions.

PHYSIOGRAPHIC EVIDENCE FOR METEORITE ORIGIN

Beach-ridge Bay.—A clear case of a bay formed amid a series of ancient beach ridges is shown in Figs. 1 and 2. It is a small bay three tenths of a mile long and is traversed by the Southport-Shallotte highway.

A detailed study of this bay was made and, contrary to Melton's (Melton and Schriever, 1950) interpretation of the same area, the field data show definitely that the bay was formed subsequently to the beach ridges. Melton states: "In Brunswick County, N. C. beach ridges of an elevated marine terrace shore, probably the Pamlico, have apparently been constructed across many large and small bays." The writer has studied this area intensively and with the aid of the contour maps recently released, a clarification of this strategic area is possible.

The small bay (Station 3, Fig. 2) lies at an elevation of 43 feet and on the low seaward margin of the Penholoway terrace. The Talbot terrace between the Pamlico and the Penholoway is very narrow at the Cape Fear prominence.

South of and close by the Beach Ridge bay a shallow valley cuts across the much flattened beach ridges, with branches leading perpendicularly out from it occupying the interridge depressions. The truncated ends of these laterals are definitely indicative of sudden rim formation followed by the flattening process of raindrop erosion which, as the surface sand moved toward the interridge depression, established a steeper gradient. The details of this physiographic evidence are shown in figure 3; a and b are transects from the bay—a on the ridge, b ending in the truncated lateral. Above are the surface profiles drawn to scale. Note the steep slope of b at the point of truncation, with peat present in depth at its base.

Such a combination of surface features could never have developed if this small bay had been formed by a process of slow depression. Such theories completely neglect the role of vegetation in keeping the basin filled with peat. With no open water, no rim of any kind would be built. Further, the surrounding forest with its herbaceous and leaf mold ground cover (only temporarily removed by fire) would prevent any significant movement of the coarse sand by the wind.

From the field data, the best theory to explain the terrain at the Beach Ridge bay, and others similar to it, is the meteorite concept. Following the original impact, with the finer sand widely dissipated, the higher and steeper rims of coarse sand were rapidly flattened by the rains since the protective vegetation was completely destroyed. Wherever sand is moving into a depression a steeper gradient will be maintained as is to be noted with moving dunes. Eventually, with the return of the vegetation, the surface forms become preserved. The ponds and lakes not only fill with peat but in the generally flat non-draining terrain of this beach ridge area, the swamp forest peat may easily have developed over the low rims and the beach ridges, affording complete protection from any erosion through many millenia.

FIG. 1. Composite air photo of bays near Southport, N. C.

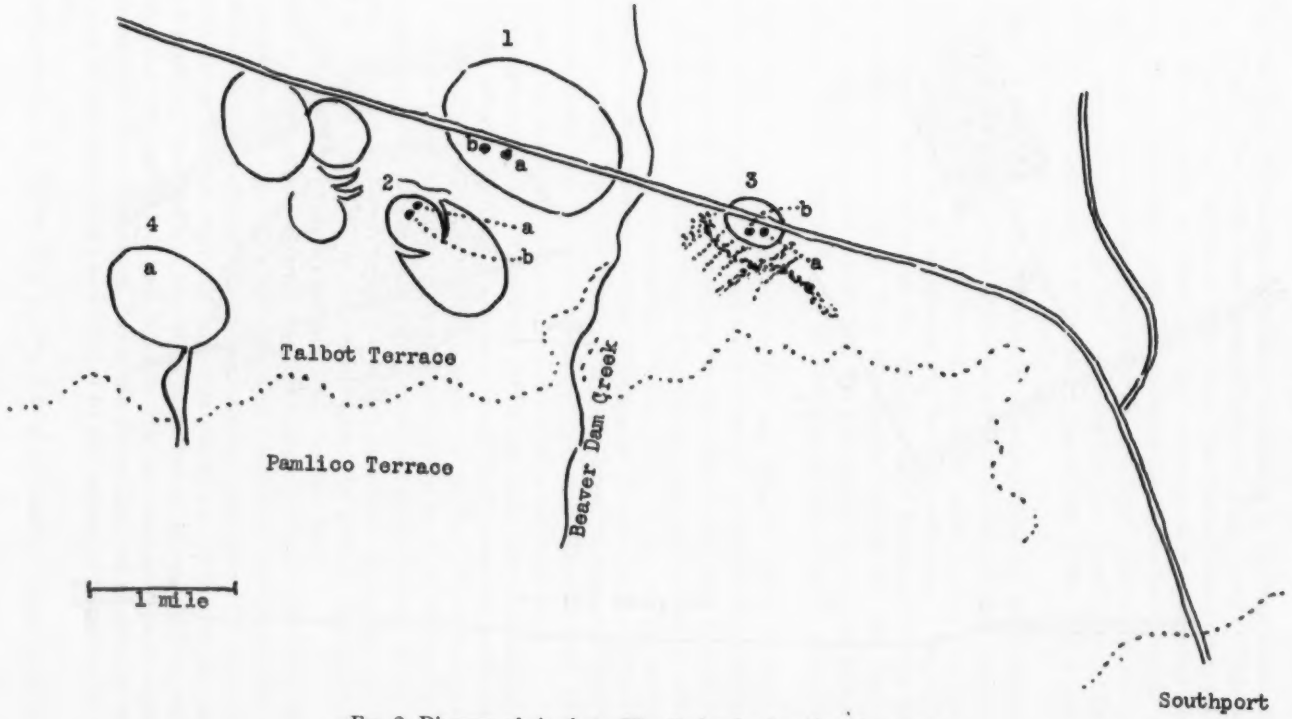

FIG. 2. Diagram of air photo (Fig. 1) showing location of stations.

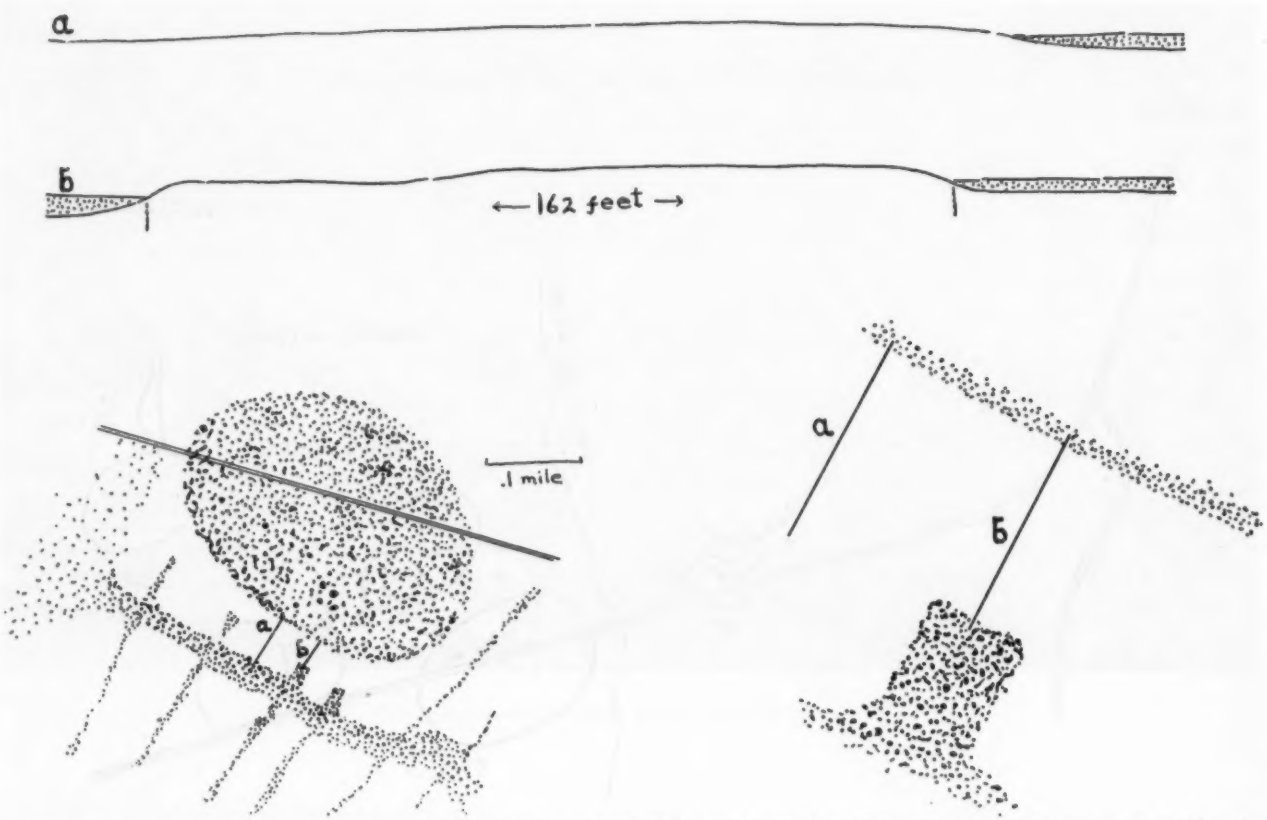

FIG. 3. Beach Ridge bay showing truncation of inter-ridge depressions by rim sand. a. Transect where rim merges into ridge. b. Transect to truncated depression. Profiles above.

Outwash Bay.—Physiographic evidence indicating a bay depression to have been originally filled with water is noted in Bay 4 (Figs. 1 and 2). This bay rim has a cut in it 75 feet wide and 15 feet deep. The channel immediately below the rim cut flares notably in width and then contracts as it approaches the well marked top of the Suffolk scarp. The contour map gives the elevation on the rim as 60 feet. The bay is not a large one (¾ mile long), yet level measurements gave the bottom of the bay as 8–12 feet below the rim. Since the peat filled bays of this size show rims only 1–2 feet above the surface of the central area, it is clear what happened in the case of this bay.

Not long after the sudden creation of the lake following the meteorite fall, there occurred a break through of the rim during a period of heavy rainfall, which permanently drained the lake leaving its coarse sand bottom exposed. This outwash is believed to be responsible for the sharp widening of the valley just below the rim. Bays tapped by the slow process of headward erosion show no such expansion of the valley. That the channel through the rim was not the work of headward erosion is shown by the fact of four feet of peat formed in it. Headward erosion streams do not fill with peat at their juvenile upper ends.

Blythe Bay: A record of bay age.—This bay (Figs. 4 and 5), located in the suburbs of Wilmington, N. C. just south of the city, is notable for its buried peat, presenting a profile which makes possible an estimate of its age. The attention of Dr. Prouty was called to this bay and a brief discussion of it together with the air photo is presented in his monograph (Prouty, 1952). Located at the eastern edge of the Penholoway Terrace, this bay is unique for its evidence of a minor fluctuation of the falling Talbot Sea resulting in a tidal break-through and deposition of mineral sediment over the partly developed peat moss. The meteorite fall must have occurred during the lower sea level involved in the fluctuation.

Before presenting the details of the profile and their interpretation, attention should be called to the large coarse sand mass which covers the north-most end of this bay. The top of this sandhill is about twenty feet above the bay surface which at the point of contact is covered with a thin layer of peat resting on the tide deposited silt. This sandhill is part of an old shoals formed by the falling Talbot Sea, since it extends well above 40 feet. Its present extension over the bay end is believed to be due to raindrop erosion, the gradual movement of the coarse sand particles under the impact of the heavier rains.

This sand truncated bay gives evidence against a solution-lacustrine theory, for on the basis of that concept the bay end would have been rounded by shore current erosion operating against a long stabilized sand mass. The more reasonable picture is that the meteorite impact produced a steep side to this sandhill which gradually flattened out, first filling in the end of the original lake, and later moving out over the silt and peat deposits. The very open and sparse vegetation of the sandhill plant community, due to fire, favors raindrop erosion, for most of the area is bare sand surface as indicated by the intense whiteness in the aerial photo.

Returning to the Blythe Bay profile, it is of the greatest importance to have

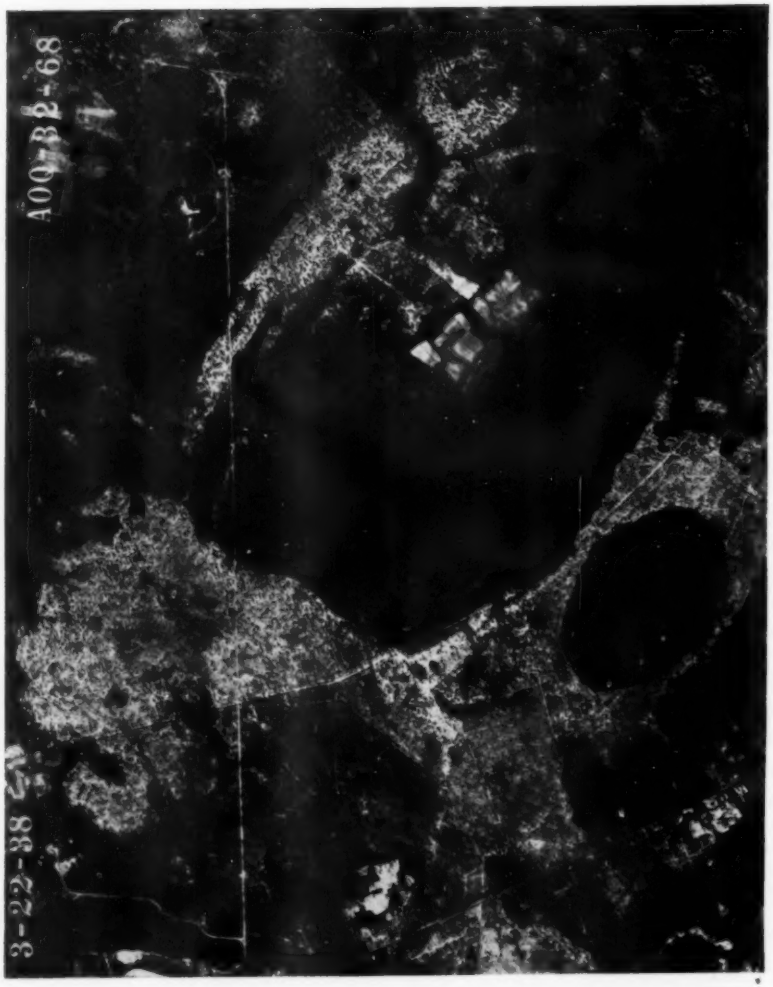

FIG. 4. Blythe bay in suburb of Wilmington, N. C. Farm in center on mineral soil deposited over peat mass.

an accurate measurement of its elevation since a minor fluctuation of sea level is recorded, during which the bay was formed. Prouty estimated its altitude at 50 feet. The recently released 20 ft. contour interval quadrangle indicates it to be between 35 and 40 feet. Based on the next lower or 20 ft. contour line local data give the bay surface at or near 36 feet elevation above mean sea level. A contour datum on the rim gives 40 feet.

The profile and its location in the bay are shown in figure 5. The peat in the drainage ditch where it was exposed was observed to become thinner away from the profile station. This latter point, it is to be noted, is located in the area which

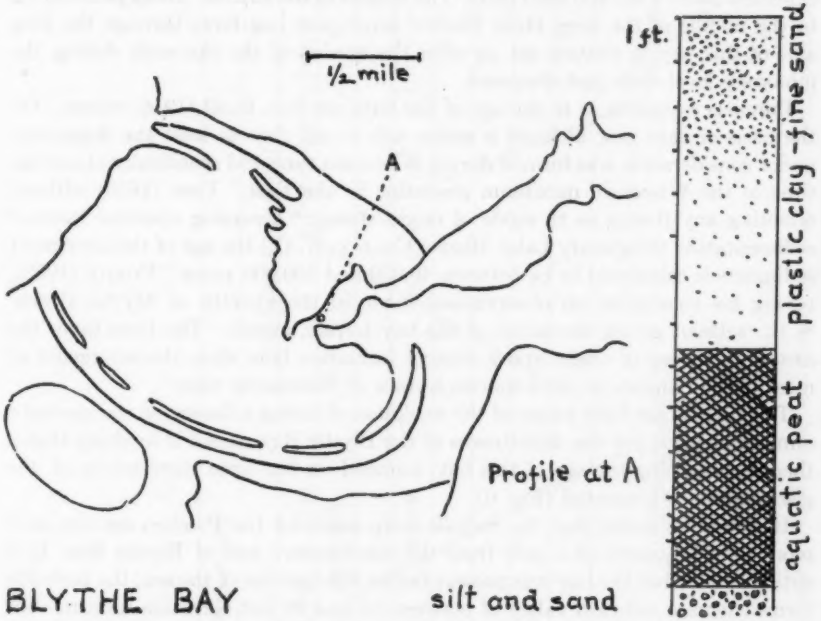

FIG. 5. Diagram of Blythe bay showing profile at station near center.

is deepest in most of the bays. The transition to the plastic clay is sharp, indicating a sudden re-entry of tidal sound water initiating seven and a half feet of the mineral sedimentation. This bay, though lying at a lower elevation than Outwash Bay, shows a similar flaring of the small valley draining it, suggesting a similar sudden break through of its rim after the scarp was developed near and below it. Blythe Bay with a deeper basin between its center and southeastern end did not drain completely. It was possibly in this restricted shallow lake that the five and a half feet of peat developed. It was noted that the peat became thinner toward the rim, the base rising. Later, with the rise of the sea involved in the minor eustatic cycle already suggested, estuary tidal currents charged

with fine sand silt and clay from the nearby mouth of the Cape Fear River became deposited over the peat to a maximum depth of seven and a half feet.

A similar bay which had suffered complete removal of the rim ends may be observed on the northern side of the great Holly Shelter estuary bay in Pender County, N. C. This bay has a slightly lower elevation than Blythe Bay, approximately 32 feet. This bay has both ends removed and much of its surface is fine sand alternating with shrub-peat bogs in local depressions. A six foot soil borer did not disclose any peat below. Excessive water prevented deeper penetration. The history of this bay is believed to be similar and aquatic peat is to be expected under a silt and sand layer. The longest of the shallow creeks penetrating to the middle of the large Holly Shelter shrub-peat bog flows through the long axis of this bay, a relation set up after the erosion of the rim ends during the minor sea level cycle just discussed.

Previous estimates as to the age of the bays are few. Buell (1946) states: "On the basis of data now at hand it seems safe to say that at least the depression under consideration was formed during Wisconsin time and specifically about the time of the Wisconsin maximum glaciation in the East." Frey (1951) without adopting any theory as to mode of origin states: "Assuming constant rates of sedimentation (Singletary Lake, Bladen County, N. C.) the age of the lowermost sediments is calculated to be between 40,000 and 100,000 years." Prouty (1952), basing his conclusion on observations made in the vicinity of Myrtle Beach, S. C., without giving elevations of the bay terrain, states: "The facts favor the meteorite theory of origin and a time of formation later than the emergence of most of the Pamlico or latest marine terrace of Pleistocene time."

The authors are fully aware of the weakness of basing a theory on too limited a number of bays, yet the definiteness of the Blythe Bay record is so sharp that a theory concerning the age of this bay, founded on the time correlations of the glaciologists, is presented (Fig. 6).

It should be noted that the Suffolk scarp made by the Pamlico sea lies little more than a quarter of a mile from the southeastern end of Blythe Bay. It is entirely clear that the bay was present before this last rise of the sea; the perfectly formed terrace outwash valley of between 15 and 20 feet elevation indicates the well recognized level of 25 feet of the Pamlico.

To locate the sea level fluctuation which resulted in the Blythe Bay sedimentation, we must go back to the falling Talbot Sea correlated with the advance of the Illinoisan glaciation. Using data summarized by Flint (1947), the estimate of a minor fluctuation between 40 and 20 feet comes out at 250,000 years.

THE PROBLEM OF THE BAY LAKES

A restricted number of Carolina bay basins have lakes in them but the water does not cover all of the depression. The northwest ends of all of them contain peat which is slightly elevated above the water level. Peat is also spread over the central areas of the lake bottoms. Most of the bay lakes are located in Bladen County, N. C. and these have received the most attention on the part of Carolina bay students.

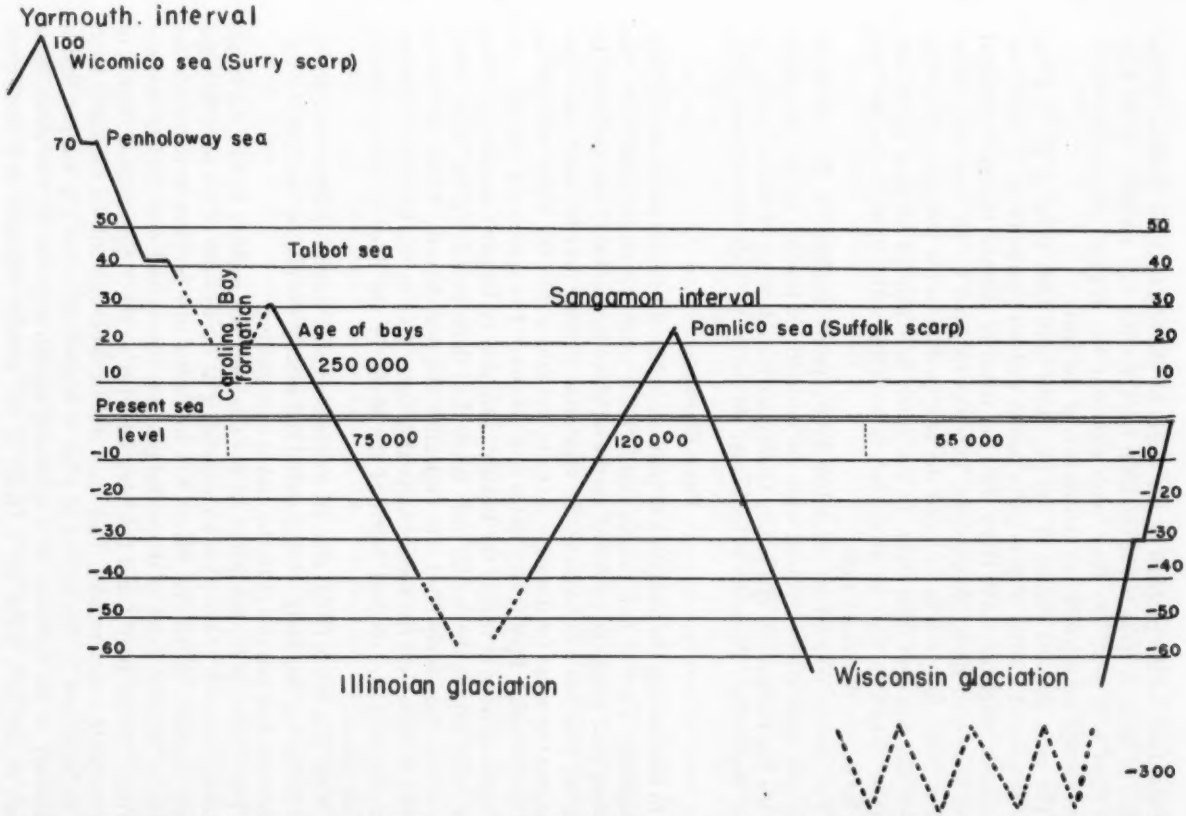

FIG. 6. Diagram of late Pleistocene sea level fluctuations showing the minor cycle during which the meteorite shower occurred forming the Carolina bays. Based on evidence from Blythe bay near Wilmington, N. C.

Subsidiary to the problem of the origin of the basins is the problem of the origin of lakes in these few exceptional bays, for the vast majority of the bays are filled with peat. Do these lakes represent the original ones or have they been formed subsequently by destruction of the peat?

The most detailed studies of the bay lakes have been those of D. G. Frey. He terminated a series of descriptive papers with an interpretation of three peat profiles in Singletary Lake (Frey, 1951) in terms of climatic changes correlated with Wisconsin glacial fluctuations. This was followed by an expanded survey (Frey, 1953) in which he included the peat profiles in the bottom of five other lakes and two peat filled bays. In the latter, he organized his peat layers into "zones" which in turn he attempted to correlate with climatic changes back as far as late Wisconsin time.

Two serious deficiencies invalidate Frey's profile studies: (1) His refusal to face the implications involved when he reversed his position on the movement of the bog margin. (2) His totally inadequate consideration of fire in relation to peat destruction. These are so important they must be dealt with in some detail.

Peat Erosion

In interpreting the formation of peat which fills the northwestern end of Lake Singletary, Frey at first follows Buell (1939) when the latter states that "the fibrous peat along the protected northwest shore has probably resulted from the trunks, branches and leaves of the vegetation growing near the shore and overhanging the water for distances up to 12 feet falling into the water and sinking to the bottom." Frey (1949) states it as follows: "The apparently constant rate of areal decrease in four of the Bladen Lakes may be largely coincidental. There are many bays in the coastal plain larger than those containing the lakes which have been completely filled with vegetation and peat deposits. Either the rate of filling in these bays has been considerably faster than in the lake bays, perhaps varying with the original depth of the basin, or the filled in bays represent older basins."

Wells and Boyce (1953) showed conclusively that no such process resulting in an advancing bog margin was possible and exactly the reverse was true—everywhere the bog margins of the bay lakes were eroding.

Frey (1953) in his last paper adopts this view but neglects to face the implications involved. If the lakes are expanding at the expense of the peat, how did they originate in the first place? Not to discuss this problem is a serious deficiency. Further, much of the eroded peat has been spread over the lake bottoms (Frey's "pulpy peat") and has been included as the "upper organic layer" of presumably intact profiles. This most serious deficiency will be discussed later.

So important is this matter of what is happening at the bog margin, that a summary of the evidence for a retreating margin is given. (1) The shrub bases next to the open water are a tangle of old mature rhizomes and rootcrowns exactly comparable to those many feet back from the margin or to be found in any fire-matured shrub bog. (2) The number of stems arising from the shrub bases (a response to fire) is just as great as far back in the bog. So dense are the

massed stems right to the water's edge that it is difficult to make a landing without a machete. (3) Stems from the same base at the water's edge show many rings indicating the time since the last fire. No new basal shoots were present anywhere. (4) All shrub roots extending into the water were dead, following the removal of peat around them by wave and current action. (5) The bush masses which finally, through rotting of their connections with the landward root mass, fall into the water do not sink immediately to contribute to peat formation but may float away to decay where they are washed up on the sand beaches. The opposing theory demands that new shoots and mature stems occupy the fringe zone at the same time, an obvious impossibility. Certainly the amount of fringe shrub material available between fires could not possibly furnish organic matter enough both to expand the bog margin and to be the source of the widespread layer of "pulpy peat" as was suggested by Frey (1951). (6) At a time of low water (fall of 1952) the peat margins nowhere are seen to slope into the water but are nearly vertical, and where peat occurs on the east side of the lakes (Jones, Salter) definite undercutting is to be noted with concomitant exposure and death of roots. Further, no peat is found on the shallow bottoms in front of the eroding peat mass. (7) Cypress and gum trees out in the water, instead of initiating "islands," are demonstrably relict trees of the former swamp forest, which have had their much contorted horizontal roots exposed by the erosion of the peat around them (Fig. 7). Examples of these are abundant in Salter Lake. Swamp gums were also noted which had suffered the same fate as the bog margin receded.

The evidence from the exposed roots is in itself conclusive. Had these outlier trees become established on the sand bottom at a time of low water their roots would have developed in the soil below the water and would never have become exposed. But for all the trees isolated along and close to the bog margin, the exposed roots tell the story of erosion of the peat around them leaving them as dead or declining relicts, indicating the former existence of the bog on which they became established. In the case of the trees isolated earlier and further from the margin, time has been sufficient for the decay of the exposed roots, the trees at the present being supported by a mass of the enlarged roots immediately beneath the trunks.

In a series of the five lakes (Fig. 8) arranged according to size, the progressive attainment of the asymmetric shape is correlated directly with increasing size. The explanation for this is probably based in the observation that the peat is eroding faster on the north and northwest sides, a fact to be correlated with the prevailing south and southwest winds. Both wave and shore current are involved in producing this characteristic shape.

With this proof of the eroding margin and the consequent distribution of the disintegrating peat over the deeper and quieter central areas of the basins, a most serious error is made by Frey when he regards such sediment as a part of a continuous profile. He only recognizes this fact of peat erosion and "redistribution" in his last paper (Frey, 1953).

The following contradictory quotations are to be found in that paper. "The

FIG. 7. Cypress roots exposed by erosion of the peat surrounding them.

expansion of the lakes has resulted in an erosion of the littoral peat deposits and a redistribution of these materials within the lake basin" (he means the expansion is the result of the erosion). Describing Little Singletary Lake he states: "The record is quite confused, perhaps through alternate deposition and erosion of littoral organic sediments as a result of expansion (sic) and contracting of the lake area." Yet under his "basic assumptions" he writes: "Considering the overall pollen succession for the region, there do not appear to be any pronounced discontinuities in the record at least none of the magnitude of thousands of years. The record is believed therefore to be essentially continuous."

If one were to accept Frey's extraordinary estimate of the rate of peat formation in the bays (Frey, 1948) at one inch every 730 years, and realize that these eroding peat walls are three to six feet deep with all levels contributing to his "upper organic layers" spread out over the lake bottoms, his "thousands of years" magnitude would be readily met.

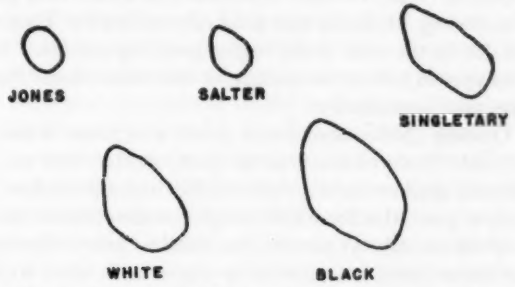

FIG. 8. Bladen Lakes: Correlation of size and shape of water bodies. All to same scale from air photos.

Having shown that the lakes are enlarging, the question must immediately be raised as to how the original water body came into existence, in which water body the initiation of the erosion took place. There is but one answer to this inquiry.

FIRE

The theory is offered here that the present Carolina Bay Lakes owe their origin to local destruction of peat by fire during an extended period of extremely low water tables such as might have occurred in the well recognized, post-glacial, warm, dry period (Atlantic of Europe), which occurred between four and six thousand years ago, according to Deevy (1952). Upon later filling with water, shore erosion followed by peat disintegration has steadily enlarged them.

It cannot be overemphasized that the Carolina Bay Lake bays are located on flat uplands where at present the water table may fluctuate as much as two to three feet within a year. And given a series of dry years alternating with wet years the fluctuation may be much greater.

Indirect evidence for an occasional extreme lowering of the lake levels is to

be noted in the disappearance of the lotus (*Nelumbo lutea*) from a bay lake. Bartram (1928) who traveled through the Bladen lake area in 1788 states: "I have observed an aquatic plant (*Nymphaea Nelumbo*) in a large pond or lake near the Cape Fear River in North Carolina which is about 2 miles over and 12 feet of water, notwithstanding which its surface is almost covered with the leaves of this plant. It also abounds in Wakamaw Lake near the same river."

The only lakes near the Cape Fear are Carolina Bay Lakes, yet no lotus has been reported from the smaller ones like the one first mentioned. If still present in Lake Waccamaw, the air photo gives no indication of it. Only an extreme lowering of the lake level could account for a complete elimination of this plant. It is well known that aquatic and marsh plants are killed en masse when the water table drops a foot or two below the surface for an extended period.

Before developing the fire concept in relation to the origin of the Bladen lakes, attention should be directed to three examples of possible fire made lakes.

Lewis and Dowding (1926) describe a shallow lake a mile long near Edmonton, Alberta which is eroding its banks and gradually enlarging. They found definite evidence of past fire in the peat of the region pointing out that "fires were more frequent and widespread before the coming of the white man." No evidence was found indicating peat aggradation.

Beaven and Oosting (1939) describe in detail a cypress swamp in Maryland in which a fire (1931) "lowered the ground (peat) level so that an extensive area became covered with shallow water in spite of the drainage ditches" **** "Due to the accumulation of peat, the fire which swept the area burned most persistently near the center of the swamp. At present this area has practically no accumulation of peat and the lower parts are covered in places with open water several feet deep. The bottom is hard and no plants have yet (1939) become established in the deepest spots."

Scattered in the great peat areas of the lowest coastal plain terraces (Pamlico, Talbot and Penholoway) are a number of shallow lakes such as Catfish, Great, Ellis and Pungo which are generally regarded as fire made. These lakes are highly irregular in shape and have been developed in the peat of broad estuary bays. The Bladen lakes are comparable in origin and differ in that they are confined within the regular sand rims of the meteorite made depression. It is on the fringe of the former estuary bays that the "farms burn." On these peatland farms smouldering fires have persisted for months in the drier years destroying the peat to the underlying sand.

To emphasize the role of fire in peat removal and the consequent appearance of open water, data from the Holly Shelter estuary bay are pertinent (Wells, 1953). In June, over a water table only four feet down a single fire removed 12 to 14 inches of peat over a large area on the east side of the bay. On the west side where the fires were more frequent, the peat had been lowered so that throughout a summer of relatively frequent rains, the water fluctuated between ten and twenty inches above the surface. The repressed low shrub mass, however, deceptively hid this large shallow lake. Later flying over this large bay disclosed a number of local fire made lakes of many acres in area, which are not shown on any maps due to their inaccessibility.

The role of the Indian initiated fires in setting up vegetational fire seres is becoming clearer. Vast areas of shrub bogs and savannas (on mineral soil) which Bartram (1928) described are to be ascribed to the increase in fire with the advent of the Indian in the southeast possibly as early as 10,000 years ago. This is sufficient time to make valid the concept of fire cycles in peat destruction and deposition related of course to precipitation cycles and consequent major shifts of the water table. In the southeastern coastal plain fire has negated any possibility of significance of peat profiles as measured from the surface. And this is true no matter whether the surface is above or below the water of the shallow lakes.

Direct evidence for removal of Carolina Bay peat by fire is given by Buell (1946) from Jerome Bog located but a few miles distant from Singletary Lake. He found charcoal fragments to the bottom of the black peat which overlaid the whitish silt (dust storm) deposit. This was at a depth of five feet.

Frey (1953), in presenting data from Jerome Bay contributed by Buell, attempts to minimize Buell's clear cut evidence of the presence of charcoal to a depth of five feet. Buell correctly states: "There is no question that fire is and has been for a long time the dominant factor concerned in the control of the communities. The universal distribution of the underlying black peat testifies to a long continued addition of charcoal to the accumulating deposit."

Frey (1953), forced to recognize these facts, involves himself in the following impasse: "Fires certainly are important in the coastal plain and evidences of repeated fires are readily apparent in almost every bay entered. Yet the writer has found definite charcoal fragments very rarely in the cores examined thus far. There is little evidence that fire has destroyed any appreciable portion of the pollen record in the basins considered in this paper."

Buell's and the writer's pollen slides uniformly show evidence of charcoal from the superficial layers in contrast to the deeper layers. The presence of charcoal may be detected macroscopically by the darker shade of the charcoal containing slide.

Another instance of conflict between Frey's data and his interpretation may be pointed out here. In none of his profiles is spruce pollen reported above five feet. If in the Singletary bog where the "intact" peat of the northwest end rises slightly above the lake surface and had developed at the incredibly slow rate of one inch in 730 years (as suggested by Frey), spruce pollen in relation to the last glaciation (10,000 years) should be found at a shallow depth of 15 inches. Again, these facts point to peat destruction and rebuilding in the recent millenia after the spruce was eliminated under the changing climate.

In relation to depth of peat burning it is of interest to note that Singletary, White, Jones and Salter are all in alignment along a northwest-southeast axis. A single fire at a time of extremely low water tables, driven by a southerly wind (the prevailing wind of the summer season) may have set up the original depressions later becoming the shallow water bodies now found in the four lakes mentioned. With the three most northerly lakes, sand rims would tend to protect the bays from fire, except on the south side, which in each case show branch bays to be closely contiguous to the Carolina Bay vegetation. Under a southerly

wind the original depression axis would approximate a north-south orientation, a feature readily observed from the air photos.

It is to be observed also that the Bladen Lakes lie in a soil region of coarse porous sand, through which water moves readily, as may be demonstrated by use of dyes as described later. On a seepage basis the tables of the bays nearest the deeper and larger stream channels would be lowered to the greatest depth, favoring peat destruction by fire.

POLLEN PROFILE INTERPRETATION

Frey, in his last two papers, developed pollen profiles of peat and silt in the bottoms of six lakes and from two filled Carolina bays. He further attempted correlations between these and also drew up a "generalized profile" ascribing "zones" which in turn he attempted to correlate with ages from late Wisconsin glaciation to the present.

It has been shown that there cannot be an unmodified peat profile in any Carolina bay primarily because of the recurrent destruction of peat by fire. And in the case of the submersed organic layers of the lakes, lateral erosion of the bog peat in their northwest ends, followed by the spreading of this peat over the bottom areas, negates any interpretation of these layers as part of a continuous or unmodified profile. The "upper organic layer" of Singletary which was radiocarbon dated at 10,224 years was of this reworked peat from the margin and represented a composite sample made up of peat of widely different ages including the present. The deeper layers gave "greater than 20,000 years."

With no evidence of any kind other than "greater than 20,000 years", Frey correlates his lower "zones" with the Mankato, Cary and Tazewell sub-stages of the Wisconsin glacial period. He believes: "The lowest organic layer (Singletary) has a probable age between 30,000 and 100,000 years." With the superficial peats profoundly and repeatedly disturbed and the deeper silt bearing organic layers "greater than 20,000 years" it is obvious that there can be no validity to these attempted correlations.

Frey's use of oak and pine percentages to indicate different climates is made invalid by the fact that all through the Carolina Bay region longleaf pine (*Pinus australis*) and turkey oak (*Quercus laevis*) both occur on the bay rims and between, where the upland sand is coarse. They vary in relative dominance owing to change in fire incidence. From the soil point of view the trees are ecological equivalents and are the only two trees abundant on the coarse sands. If a crown fire destroys the pines, the turkey-oaks will come to dominance. With frequent ground fires the oak will be checked but the pines remain unaffected.

Frey gives little attention to the problem of the origin of the silt found in the lake bottoms and larger filled bays as well, passing it off with the suggestion that it may have blown in from "outwash glacial plains" of the west. Our suggestion that it represented the finer material that would be blown from the inter-bay areas was shared with Prouty and is presented in his monograph (1952). Recently the writers poured some coastal plain sand in front of a fan and catching the finer material which was carried across the room, we compared it micro-

scopically with silt from Singletary Lake and found it impossible to distinguish between the two. Both were composed chiefly of silt size particles of quartz. Anyone who has seen dust storms which on windy, dry days sweep across the open fields of the coastal plain, will have no difficulty visualizing the origin of the thick layer of silt in the bottoms of the larger bays.

It may be pointed out that the presence of these large amounts of silt in the bottoms of the larger bays, silt which could only be of aeolian origin, constitutes positive evidence for the catastrophic origin of the depressions by meteorites. In a region which is known to have been forested throughout all of Pleistocene time dust storms of the magnitude necessary to account for many feet of deposits are inconceivable. And any theory involving the slow depression of the surface making possible the immediate appearance of woody peat cannot possibly explain the presence of these layers of silt in the bay bottoms. The presence of water lily pollen in the silt tells the story of the early invasion of the region by aquatic plants.

With all these attempts at dating his layers including the silt strata, Frey never discusses the physiographic problem of the origin of the Carolina bay basins, which has an all important relation to the age and history problems.

WHITE LAKE

White Lake must be especially dealt with on account of the remarkable clarity of the water—clear, as an indoor bathing pool. All the other lakes are of varying degrees of "dark water." In spite of the known facts of artesian water entering the lake bottom, Frey (1948, 1949) developed a new theory to explain the clear water based on the fact that the small drainage outlet is located on the bog side where the dark bog water supposedly drains away before contaminating the lake. Many years ago one of the authors (Wells) was fortunate in locating the point of entry of the artesian water. The sand was observed boiling over a number of orifices and to such a degree as to indicate a large volume of water entering the lake bottom. Knowing this fact and then later observing that during times of extended drouth the outlet stream came down to a mere trickle, two logical conclusions follow: (1) were no artesian water entering the lake, the extended bog margin would quickly begin to color the water certainly adjacent to the bog material. But this is never observed. (2) Knowing that water is entering the lake from below the lake surface a "head" of water relative to the surrounding ground water table would be expected to result.

It occurred to us that if such a head is established, movement of water from the lake into the shore sands might be demonstrated with the aid of a soluble dye (fluorescin was used upon the suggestion of Dr. L. A. Whitford).

Three wells six inches in diameter were set up as indicated in figure 9 on the sandy shore of the southeast side of the lake. Wire door screen was used to hold back the sand. In twenty-six hours the brilliant green dye had been completely eliminated from the front well, carried through and beyond the second, with just enough left in the third well 10 feet from the shore to indicate its passage through the coarse sand in a direction away from the lake. There was no change

in the position of the shore water line since during the entire period there was little or no wind. These results are graphically summarized in figure 9.

This demonstration of water movement from the lake into the surrounding sand rim was made at a time when the lake was low and no water was flowing out of the only known outlet or break in the rim.

In contrast to the White Lake demonstration, a fluorescin colored well at Jones, a dark water lake, showed not the slightest change in 14 hours.

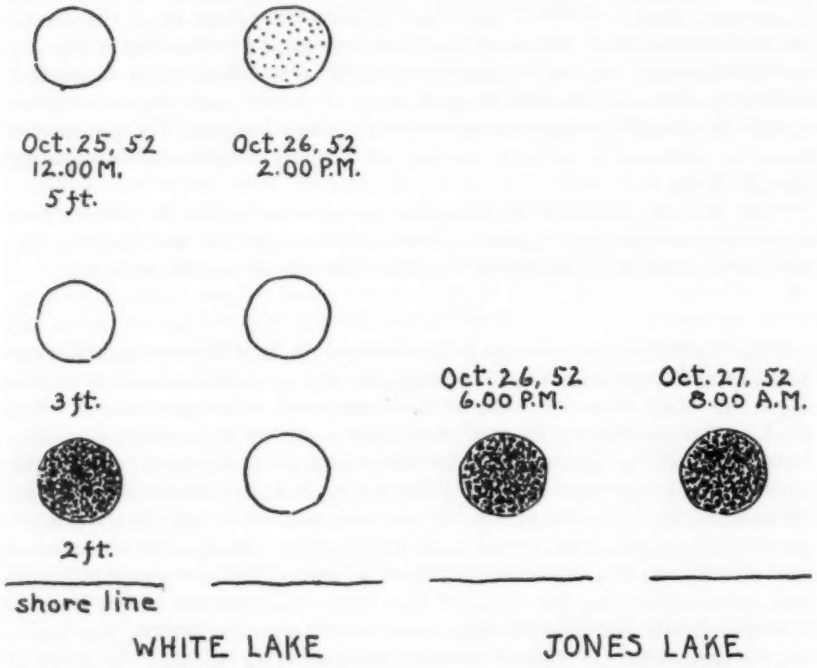

FIG. 9. Dye (fluorescin) demonstration of movement of clear water in White Lake into the sand rim shore indicative of artesian source. No such movement of the dark water in Jones Lake. Circles are shallow wells.

White Lake is thus to be regarded as a huge artesian spring. The clarity of its water could not possibly be maintained on the basis of the slow movement of the ground water into the lake as Frey suggests.

It should be pointed out that the lake level is still determined by the height of the regional water table. The ready seepage through the coarse sand surrounding the lake would always prevent the lake surface from rising but slightly above the environing water table. The story of peat formation and peat destruction is just as true for White Lake as for the dark water lakes. The major water table cycles are closely approximate for all.

OUTLINE OF CAROLINA BAY LAKE ORIGIN AND HISTORY

It is now believed possible to construct a reasonably clear story of these unique areas in the coastal plain of North and South Carolina. At least the new concepts introduced may furnish points of attack and thereby further the progress of investigation.

A quarter of a million years ago, a vast number of small meteorites coming in at a low angle from the northwest produced in the unconsolidated, surficial sands innumerable steep-sided elliptical basins with prominent rims. These quickly filled with water, the landscape becoming dotted with ponds and lakes. The higher winds, blowing across the open, now deforested region, deposited the white siliceous silt so prominent in the bottoms of the larger bays. This deposition was rapid at first, since the heat and explosive pressure waves annihilated the protective forest. The silt deposition continued at a lesser rate as the trees returned until with complete reforestation (including shrubs) the process practically ceased. Later during a period of drouth, fire may have so profoundly destroyed the upland vegetation as to again initiate silt deposition. With water and aquatic plants still present in the deeper areas, the presence of the intercalated organic horizons reported by Frey could be explained. The rims were early reduced to their flattened and highly stabilized condition largely by raindrop erosion.

The uniform presence of aquatic pollen mixed with silt and in the organic layer of undisturbed peat lying on the silt (filled bays) suggests that the aquatic plants may have played the major role in the formation of first peat layers. Presumably aquatic peat deposition would go on until the peat became exposed by the fluctuating water table, when temporary surface aeration would make possible the establishment of the swamp forest trees (swamp gum and cypress). During the Wisconsin glaciation there may have been a shift to the northern or muskeg trees (spruce and larch). For millenia preceding the onset of Indian-made fires, it is believed that some type of swamp forest dominated these areas. However, all of this superficial swamp forest peat has been destroyed by fire.

With the high fire incidence of the Indian occupation, not only were the lakes initiated, but the well known fire regressive succession took place and reduced most of the filled bays and the bog ends of the lake bays to the fire tolerant (through regeneration by shoots) shrub-bog plants. As Buell (1946) has shown, the upper peat layers have burned and been replaced many times, making impossible any dating based on the premise of continuity.

In light of the evidence for extensive destruction of upland peats by fire, it is believed that during the warm dry period of post-glacial time (four to six thousand years ago) the peat was locally destroyed in certain bays near deep drainage basins thereby initiating the present lakes.

Once these small shallow water bodies were formed, they became enlarged laterally through erosion of the surrounding peat under wave and current action. For some unknown reason little aquatic or marsh vegetation is now found in them, hence there is no significant sedimentation going on which could counteract the loss by peat erosion and subsequent disintegration. The lakes are steadily

enlarging at the expense of their bogs and at a rate which would preclude their initiation earlier than a few thousand years ago.

SUMMARY

1. New lines of ecologic and physiographic evidence supporting the meteorite theory of the origin of the Carolina Bays is presented.

2. A bay with buried peat is described which gives an index as to the age of the depressions viz. 250,000 years.

3. The problem of the origin and enlargement of the bay lakes is discussed and it is suggested that fire originated them in post-glacial time, and shore erosion has enlarged them at the expense of the remaining peat.

4. Because of the demonstrated extensive peat destruction under the high fire incidence since the coming of the Indian, and the distribution of peat through erosion, all attempts to use pollen profiles to interpret past climates correlated with late Wisconsin glacial stages, are futile. (Frey, 1953). Intact profiles are unknown.

5. The unique clear water body (White Lake, Bladen Co., N. C.) is shown to be a huge artesian spring and its clarity is not to be explained by Frey's drainage theory.

6. An outline story of Carolina Bay origin and history is presented which involves their catastrophic origin; the rapid filling with silt from the surrounding devastated region; the development of aquatic peat to a point where a swamp forest of some type could be established followed in post-glacial time by the extensive reduction of the forests to shrub-bogs and through local deep burning of the peat; the establishment of lakes in a small number of bays located near deep river drainage courses.

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FOOD HABITS OF THE MOURNING DOVE IN NORTH CAROLINA*

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It is well established that the Mourning Dove (*Zenaidura macroura*) is a 99% vegetarian, feeding almost exclusively on the seeds of a wide variety of both wild and cultivated plants (Martin, Zim, and Nelson, 1951: 111–112). Knappen (1938), comparing the contents of 219 Mourning Dove stomachs from the southeastern states (6 from North Carolina) with "nearly 1,000" from all over the United States, showed that in both sets of samples the four most important food groups were grasses, legumes, composites, and spurges, the main species in the southeast being Corn, Bristlegrass, Egyptian Grass, Cowpea, Crab-grass, and Ragweed. Rosene (1939) analyzed 287 stomachs collected in Alabama and found the most utilized foods to be Corn, Wheat, Johnson Grass and Sorgum, Bull Paspalum, Egyptian Grass, Crab-grass, Peanut, Cowpea, and Doveweed. A localized study of 157 Dove stomachs in southwestern Iowa (McClure, 1943) listed 14 species as making up 95.5% of the volume during the breeding season, with Hemp (*Cannabis sativa*) easily the most important item. Another localized study, in southern Missouri (Leopold, 1943), determined the principal fall foods as Wheat, Foxtail, Millet, Cane, Barnyard Grass, Doveweed, Smartweed, Pigweed, Soybean, Cowpea, and Ragweed.

Most papers on the food habits of Mourning Doves have emphasized that these birds eat whatever is available to them on the surface of the ground without scratching, and with much shifting in the particular seeds taken from season to season and place to place. For these reasons, and since Mourning Doves flock to the best feeding grounds, knowledge of seasonal food availabilities and preferences is useful in population and management studies. The present paper is the first on the food habits of this outstanding game bird in North Carolina, a large state with diverse physiographic regions and associated farming types.

The physiographic regions or provinces, from west to east, are Mountains, Western Piedmont, Eastern Piedmont, Sandhills (seven counties between Piedmont and Coastal Plain on the south), and Coastal Plain. More detailed descriptions and a map of these well-known regions can be found in Quay (1951: 8, 19–21).

Collections and Procedures

An extensive research project on the biology, nesting, and populations of the Mourning Dove in North Carolina was conducted during the years 1939–1942 by

* From a thesis submitted by the senior author to the Graduate Faculty of the North Carolina State College of Agriculture and Engineering of the University of North Carolina in partial fulfillment of the requirements for the degree of Master of Science in Animal Ecology.

the N. C. Wildlife Resources Commission (Quay, 1951). As a part of this project, during 1939–1940, 731 adult Doves were shot from all over the State in all months of the year, and examined for age, weight, sex, and pigeon milk. The crops of 553 of these Doves were preserved, and form the basis of the present study.

Quantitative analyses of the crops were made by a combination of the standard "aggregate volume" and "aggregate percentage" methods (Martin, Gensch, and Brown, 1946). The contents of each crop were passed through a graduated set of sieves, and the resultant size-classes of seeds measured in cubic centimeters. The percentage volume of each species within each size-class was established by visual estimate, then calculated to cubic centimeters. The use of visual estimates within measured size-classes eliminated the tedious and time-consuming process of separating different species of small seeds of similar size, yet maintained satisfactory accuracy.

All 553 crops were used in figuring the frequency of occurrence (percent frequency or F in the text below). Only 451 of the crops were used for percent volume (V), however, or all those amounting to at least one cubic centimeter.

The sample sizes by regions are shown in Table 2. Since 43% on the volume basis and 47% on the frequency basis of all the specimens were collected in the Eastern Piedmont, the statewide data are necessarily heavily weighted in that direction.

These data apply primarily to the late summer-fall season, for 76% of all the specimens were collected between August 28 and November 30. Only in Wake County in the Eastern Piedmont were Doves collected throughout the year, and even here the late summer-fall sample amounted to 56%. For the State as a whole other than Wake County, the late summer-fall sample was 87%.

The discussion of all the material as statewide and regional samples taken largely in the late summer-fall period will be made first, followed by the year-around analysis for Wake County.

STATEWIDE AND REGIONAL PLANT FOODS

The total plant foods, all seeds, averaged 99.5% V (volume), the lowest being 97.7% V in the Sandhills (See Table 1). Total animal food averaged 0.5% V, and will be discussed later. A small group of six plant families comprised 96.4% V of all foods, varying only between 95.8% in the Eastern Piedmont and 98.6% in the Western Piedmont. This marked uniformity for all regions was achieved by substitutions only within the six families from province to province. The grasses had the highest and most uniform use, averaging 64% V. The legumes (average 13.5% V) were used from three to six times as much in the eastern parts of the State as in the western. The sedges (average 3.2% V) were used twice as much in the Sandhills and Coastal Plain as elsewhere. The primary use of the spurges (av. 6.4% V) and the composites (av. 4.9% V), however, was in the Mountains and Western Piedmont. Pokeweed was used the most extensively in the E. Piedmont—6.8% V. These statewide, average volumes for these six families in North Carolina compare very favorably with, but are

uniformly somewhat higher than, those listed by Knappen (1938: 781) both for the southeastern United States and the entire United States.

Table 2 presents a more detailed analysis. Eleven genera, each represented either by a single species or one much-the-commonest species, averaged 85.4% V of all foods taken. Again, as with the families, the total usage was quite uniform for all provinces, varying between 81.7% V in the Sandhills and 92.5% V in the W. Piedmont. These eleven genera were all classified as being in some combination of either medium or high volume and frequency.

A summary of Table 2 by genera might be helpful. Crabgrass was the single most important item (av. 17.2% V and 62% F), and constituted the record high of 28.5% V and 84% F in the Sandhills. Corn (av. 12.2% V, 26% F) was

TABLE 1

Percentage volumes of major families of plant foods.

Physiographic provinces are arranged from west to east. "Tr." means trace (less than 0.1 per cent). The number immediately under each regional heading is the sample size.

FOODS	STATE-WIDE 451	MOUN-TAINS 34	WESTERN PIEDMONT 69	EASTERN PIEDMONT 211	SAND-HILLS 71	COASTAL PLAIN 66
Plant Food:						
Gramineae	64.0	64.0	64.0	61.0	68.0	68.5
Leguminosae	13.5	3.0	4.6	18.3	13.2	14.4
Euphorbiaceae	6.4	14.2	12.6	4.6	4.7	3.9
Compositae	4.9	11.0	15.2	2.7	2.7	1.7
Phytolaccaceae	4.4	1.0	2.2	6.8	1.4	4.1
Cyperaceae	3.2	3.2	Tr.	2.4	6.4	5.0
Total, Above 6 Families	96.4	96.4	98.6	95.8	96.4	97.6
All other families	3.1	3.5	0.9	4.1	1.3	2.2
Total Plant Foods	99.5	99.9	99.5	99.9	97.7	99.8
Animal Food	0.5	0.1	0.5	0.1	2.3	0.2
Total, All Foods	100.0	100.0	100.0	100.0	100.0	100.0

taken more in the E. Piedmont and the C. Plain than in the other provinces. Foxtail was utilized *decreasingly* from the Mountains (25% V, 38% F) to the C. Plain (3.2% V, 5% F), but Paspalums were used *increasingly* from the Mountains (2.9% V, 35% F) to the C. Plain (29.6% V, 67% F). Wheat (av. 9.4% V, 16% F) was used rather uniformly except in the C. Plain (1% V, 1% F). Pokeweed reached its greatest use in the E. Piedmont, Ragweed in the Mountains and the W. Piedmont, and Galingale or Sweet Rush in the Sandhills and C. Plain. Soy-bean was eaten mainly in the eastern three provinces, Cow-pea in the E. Piedmont and C. Plain, and Croton or Doveweed in the Mountains and W. Piedmont.

It will be noticed that the five High Volume—High Frequency genera were all grasses, two cultivated (Corn and Wheat) and three wild. Of the six genera

in the Medium Volume—High Frequency and Medium Volume—Medium Frequency categories, two were cultivated (Soy-bean and Cow-pea) and four

TABLE 2

Principal genera and species of plant foods

Nomenclature according to Gray's Manual of Botany, eighth edition (Fernald, 1950). A species name in parenthesis following a genus indicates the commonest species taken in that genus. Abbreviations: V—per cent volume; F—per cent frequency; Tr.—trace (less than 0.1 per cent). The number immediately under each V and F is the sample size.

GENERA AND SPECIES, BY CATEGORIES	STATEWIDE		MOUNTAINS		WESTERN PIEDMONT		EASTERN PIEDMONT		SANDHILLS		COASTAL PLAIN	
	V 451	F 553	V 34	F 61	V 69	F 92	V 211	F 238	V 71	F 76	V 66	F 86
High Volume—High Frequency:												
Digitaria spp. (*sanguinalis*)—Crabgrass	17.2	62	15.4	49	25.0	64	13.0	62	28.5	84	11.7	51
Zea Mays—Corn	12.2	26	4.5	15	6.5	15	15.0	30	6.0	22	19.7	36
Setaria spp. (*glauca*)—Foxtail	10.9	29	25.0	38	19.4	39	11.0	37	3.4	9	3.2	5
Paspalum spp. (*Boscianum*)—Paspalum	9.8	45	2.9	35	1.9	41	6.8	46	12.4	45	29.6	67
Triticum aestivum—Wheat	9.4	16	15.0	11	9.4	16	11.0	21	10.2	18	1.0	1
Medium Volume—High Frequency:												
Phytolacca americana—Pokeweed	4.4	27	1.0	13	2.2	24	6.8	36	1.4	15	4.1	26
Ambrosia spp. (*artemisiifolia*)—Ragweed	4.5	16	11.0	14	14.7	34	2.1	12	1.7	15	1.7	12
Cyperus spp. (*compressus*)—Galingale	2.5	34	2.0	18	Tr.	16	1.4	25	5.9	63	4.9	64
Medium Volume—Medium Frequency:												
Glycine Max—Soybean	6.2	8	—	—	0.6	2	9.3	11	7.7	12	3.9	5
Vigna sinensis—Cow-pea	5.0	9	2.5	2	3.7	8	6.5	13	2.3	4	5.5	7
Croton spp. (*glandulosus*)—Croton	3.3	7	4.0	3	9.1	12	2.6	8	2.2	5	0.5	5
Total	85.4		83.3		92.5		85.5		81.7		85.8	

were wild. All six wild genera grow in currently or recently cultivated fields and around farms in general. This situation lends support to the previously

expressed belief that the Mourning Dove is "primarily a farm game species" (Moore and Pearson, 1941: 31), and that "its management would fit in well with other aspects of farm game programs" (Quay, 1951: 83).

The variations from region to region in the percentage volume use of the eleven principal genera should probably not be judged too finely. Perhaps the similarities should receive more emphasis than the differences. While the figures undoubtedly are accurate reflections of availability at the times and places of collection, yet they indicate possibilities more than continuing actualities. These foods may be considered Mourning Dove favorites, to be taken in direct proportion to availability and abundance wherever and whenever found by these birds. Also, any one or more of a number of other genera might become of paramount importance at some particular time and place, such as: Barnyard Grass, Egyptian Grass, Geranium, Lespedeza, Oat, Panic-grass, Peanut, Pigweed, Sorgum, Smartweed, Spurge, Vetch, etc.

A fourth category was composed of four Low Volume—High Frequency genera: *Euphorbia* spp. (*maculata*)—Spurge, *Panicum* spp. (*dichotomiflorum*)—Panic-grass, *Acalypha virginica*—Three-seeded Mercury, and *Polygonum* spp. (*pennsylvanicum*)—Smartweed. The total average volume of these four genera was only 3.8%. All were of low volume in every province, except for *Acalypha* which rose to 9.2% V in the Mountains.

A fifth and final group was made up of 68 Low Volume—Low Frequency genera. Most of these were less than 1% V and 5% F. Only *Eleusine* (6.7% F), *Fimbristylis* (6.9% F), *Lespedeza* (9.5% F, 0.4% V), and *Geranium* (7.7% F) were more than 5% F. The alphabetical list is as follows:

Agrostis	*Commelina*	*Ligustrum*	*Rhynchosia*
Allium	*Cuscuta*	*Lolium*	*Scleria*
Amaranthus	*Crotalaria*	*Lotus*	*Scirpus*
Ampelopsis	*Dactyloctenium*	*Mollugo*	*Secale*
Arachis	*Datura*	*Myrica*	*Sida*
Arenaria	*Desmodium*	*Oenothera*	*Sorgum*
Avena	*Diodia*	*Oxalis*	*Spermolepis*
Bulbostylis	*Echinochloa*	*Parthenocissus*	*Stellaria*
Cannabis	*Eleusine*	*Phaseolus*	*Strophostyles*
Carex	*Erodium*	*Phyllanthus*	*Stylosanthes*
Cassia	*Fimbristylis*	*Pinus*	*Tephrosia*
Ceanothus	*Galactia*	*Podophyllum*	*Tragia*
Centaurea	*Geranium*	*Polymnia*	*Trichostema*
Centrosoma	*Impatiens*	*Portulaca*	*Trifolium*
Chenopodium	*Lactuca*	*Ranunculus*	*Vicia*
Chrysanthemum	*Lathyrus*	*Rhus*	*Viola*
Cirsium	*Lespedeza*	*Rubus*	*Vitus*

In all, the 553 Mourning Dove crops examined contained seeds from 83 genera and at least 129 species.

PLANT FOODS IN WAKE COUNTY AROUND THE YEAR

One hundred and sixty-two Dove crops collected throughout the year in Wake County were analyzed for volume. The majority of the specimens were taken

from October to February, and the least during the nesting months of March to August. There was a clear and steady seasonal change in the principal plant foods utilized, however, as shown in Table 3.

The large, cultivated grains and legumes—Corn, Soy-bean, Cow-pea, Sorghum, and some Wheat—were the main foods during January, February, and March. During spring and early summer, Wheat was the most important item, and Corn and Cow-pea second and third. Wheat continued as the primary food through the summer, with the new Pokeweed and Foxtail seeds becoming important for the first time in the year. In September, Crab-grass and Paspalum seeds were the principal foods, along with Pokeweed and Foxtail. In the late-fall months of October and November, Crab-grass and Paspalum continued as

TABLE 3

Principal plant foods throughout the year in Wake County, based on percentage volumes

Genera arranged downward in decreasing order of importance with High Volume—High Frequency genera marked by asterisks (*). The number under each period is the sample size; total 162.

JAN–FEB 33	MARCH 12	APR–JUNE 10	JULY–AUG 16	SEPTEMBER 56	OCT–NOV 35
*Corn	*Corn	*Wheat	*Wheat	*Crab-grass	*Crab-grass
*Soy-bean	Cow-pea	*Corn	*Pokeweed	*Paspalum	*Cow-pea
*Cow-pea	Soy-bean	*Cow-pea	Foxtail	*Pokeweed	*Paspalum
Sorghum	Nut-rush	Soy-bean	Corn	*Foxtail	Corn
Wheat	Sorghum	Chickweed	Soy-bean	Wheat	Croton
Crab-grass	Kidney-bean	Vetch	Cow-pea	Soy-bean	Soy-bean
Pine		Corn-flower	Crab-grass	Corn	Foxtail
Galingale			Oat	Cow-pea	Ragweed
			Smartweed	Croton	Wheat
			Goose-grass	Galingale	Pokeweed
			Peanut	Smartweed	Smartweed
			Vetch	Spurge	Galingale
			Corn-flower	Corn-flower	Spurge

staples, but such winter-type foods as Corn and Cow-pea reappeared high on the list.

In general, the main winter, spring, and early-summer foods were a limited group of the large, cultivated grains and legumes. The main late-summer and fall foods were greater in variety, with the most important ones being the wild grasses and Pokeweed.

It is during the first half of the year then, before the ripening of the wild plants, that Mourning Doves are most dependent on waste grains and other seeds, unharvested crops, and planted food patches. This would be the time when the most could be done through food management procedures about attracting and holding increased numbers of Doves, both for the winter hunting season and the beginning of nesting.

ANIMAL FOODS

Animal foods averaged 0.5% V in the entire, statewide sample, there being traces of Mallophaga, Hymenoptera, Hemiptera, Coleoptera, insect eggs, insect galls, Gastropoda, Pelecypoda, fish vertebrae, and bird egg shells. The importance of animal foods, minerals, and grit in the nutrition of Mourning Doves is practically unknown, and nothing was done on these subjects in this study. A series of papers on the nutrition of the Bobwhite Quail is summarized by Nestler (1949).

SUMMARY

The crops of 553 Mourning Doves collected from all regions of the State were analyzed for volume and frequency of the contained genera and species of seeds. Specimens were taken throughout the year in Wake County, but primarily during late summer and fall in the rest of the State.

The main results are presented in three tables. Total plant foods, all seeds, averaged 99.5% V (volume). Between 95.8% V (Eastern Piedmont) and 98.6% V (Western Piedmont) of all foods were made up of grasses, legumes, spurges, composites, pokeweed, and sedges.

Eleven genera averaged 85.4% V of all foods taken, varying between 81.7% V in the Sandhills and 92.5% V in the Western Piedmont. These genera, each represented either by a single species or one much-the-commonest species, were, in decreasing order of importance: Crab-grass, Corn, Foxtail, Paspalum, Wheat, Pokeweed, Ragweed, Galingale, Soy-bean, Cow-pea, and Croton. There was a considerable degree of differential use of these genera in the various physiographic regions.

In all, the crops examined contained seeds from 83 genera and at least 129 species. These were classified in five categories of foods: High Volume—High Frequency, Medium Volume—High Frequency, Medium Volume—Medium Frequency, Low Volume—High Frequency, and Low Volume—Low Frequency. Volume was considered to be more significant than frequency.

On the basis of the year-around collections in Wake County in the Eastern Piedmont, the main winter, spring, and early-summer foods were the large, cultivated grains and legumes—Corn, Wheat, Soy-bean, Cow-pea. The late-summer and fall foods were greater in variety, the principal ones being wild grasses and Pokeweed. Crab-grass (*Digitaria* spp.) was the single most important item, with the statewide average of 17.2% volume and 62% frequency.

Animal foods, mostly insects and gastropods, were taken in trace amounts only, and averaged but 0.5% V.

Winter and spring would be the seasons when the most could be done through food management procedures about attracting and maintaining, within North Carolina, increased numbers of this second most important game bird in the southeastern United States.

ACKNOWLEDGMENTS

We are indebted to the N. C. Wildlife Resources Commission both for providing us with the study material and for making possible some assistance with the laboratory procedures.

Dr. A. C. Martin, of the Patuxent Research Refuge, U. S. Fish and Wildlife Service, Laurel, Maryland, was of invaluable help in making and verifying many of the original identifications of the seeds.

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RANGE EXTENSIONS OF RHOPALOCERA IN EASTERN NORTH CAROLINA. A CHECKLIST OF THE SPECIES OF CARTERET COUNTY, N. C.

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The Beaufort area, located in the lower coastal plain region of North Carolina, presents a wide variety of habitats for the study of many animal groups. The principal types of habitats to be found are salt marshes, coastal dunes, maritime forests, savannahs and pocosins, pine and hardwood forests, inland marshes, and meadows and fields. Excellent descriptions and studies of these plant communities have been provided by Oosting (1950), Wells (1928), and Lewis (1918).

During the season from June of 1952 to June of 1953, a faunistic study was made of the butterflies of this area and information was gathered on the habitat preferences, seasonal distribution, and relative abundances of these insects. As a result of the survey fifty-nine species were found, twenty-nine of which are new records for Carteret County (see checklist).

The information herein deals primarily with thirteen of these species whose records show new range extensions of significant distances within North Carolina; some of these represent considerable distances such as from the piedmont to the lower coastal plain, others only from the upper coastal plains to the immediate coastal areas.

The state distribution records which are listed under each species below have been extracted from C. S. Brimley's "Insects of North Carolina" and the files of the Division of Entomology of the North Carolina Department of Agriculture which were made available through the courtesy of Dr. D. L. Wray. These are included for comparison purposes. The records listed under Beaufort area include only those found by the present study. Thanks are expressed to Dr. W. D. Field for making available the collections of the U. S. National Museum and for his aid in checking the identifications of the specimens in the writer's collection.

Vanessa cardui carduelis (Cramer)

State: Mountain region, east to Edgecombe and Duplin counties.

Beaufort area: August and September.

The Painted Lady was collected in all open habitats such as meadows, roadsides, and grass and scrub flats of beaches, including the outer banks. It seemed to have preference for tall flowers, particularly *Verbena brasiliensis* and *Mikania scandens*, which were abundant around the many estuaries in the area and around Mullet Pond on Shackleford Banks.

Limenitis archippus archippus (Cramer)

State: Wake and Robeson counties, westward, May to frost.

Beaufort area: July to September.

The Viceroy was collected only rarely in the area. However, the record dates are sufficiently scattered to indicate that the species is a resident one. It is an inhabitant of open fields.

Phyciodes phaon (Edwards)

State: Fort Fisher and Smith's Island.

Beaufort area: August and September.

This species is found on grasses and flowers of Shackleford Banks, Cape Lookout, and on the west shore of the Newport River. Around Mullet Pond at Shackleford Banks, it was taken on *Lippia nodiflora* and *Dichromena colorata*, the former being reported among the larval food plants. It was visiting *Verbena brasiliensis* along Newport River.

Phyciodes phaon is nearly impossible to distinguish in the field from *P. tharos*. For this reason it may easily have been overlooked because of the large numbers of *Phyciodes tharos*. As far as the writer can ascertain, this marks the third collection of *Phyciodes phaon* in North Carolina and is the northernmost record in its known distribution in the eastern coastal states.

The dragonflies at Shackleford Banks were noted to be predators on the species.

Colias eurytheme (Boisduval)

State: Raleigh to Southern Pines and westward, whole season.

Beaufort area: June to early December.

The Alfalfa Butterfly is found in all open habitats where flowers are blooming. It commonly visits sea ox-eye, *Borrichia frutescens*, on the margins of marshes and even deep in marsh flats where this plant occurs. The preferred habitats are pastures and roadsides where clover, *Trifolium*, and sweetclovers, *Melilotus alba* and *M. officinalis*, are found.

Colias eurytheme is particularly abundant during mid-June and early September. Infrequency in collections during July and August presumably indicates a much smaller population during these months. The population remains at about the September level well into October with scattered individuals persisting as representatives of one of the last flying species of the season.

The white form of the female appeared in small numbers during the June and fall rises in population. These white females comprised 25% of the total females collected, such a high percentage being attributed to the fact that the samples could hardly be considered as random.

Papilio marcellus Cramer

State: Halifax to Bladen County and westward, whole season.

Beaufort area: March to August.

The Zebra Swallowtail is an inhabitant of woodlands and woodland margins. In savannahs it is usually seen flying close to the ground around "titis" or

pocosin areas, while in maritime stands it is found on the margins of clearings, notably around yaupon and *Smilax*.

The spring population is the light form *marcellus*. Mating was observed during the last week of March and the first week in April. The second brood is of the summer form *lecontei*, appearing the first week of June. The species is commonest in late March and early June.

Thorybes confusis Bell

State: Wilmington; April.

Beaufort area: July and August.

This species, the Confused Cloudy Wing, was first found in the area on July 10 on *Borrichia* along the coast. Shortly after, it was common in meadows and other open places.

Very little is known about this skipper. With its remarkable resemblance to *Thorybes bathyllus* and *T. pylades*, it is no wonder that it is overlooked. There is probably only a single brood in the area since it was found only during a thirty day period, during which it was collected regularly.

Erynnis juvenalis (Fabricius)

State: Raleigh, Burlington, Southern Pines, Gastonia, March to May; Black Mountain, May; Tryon, April to August.

Beaufort area: June.

This species was taken on flowers around the margins of maritime forests and infrequently in meadows. It is quite rare; only the females have been taken.

Erynnis zarucco (Lucas)

State: Raleigh, Southern Pines, Wilmington, Gastonia, March to August; Andrews, May; Aquone, August.

Beaufort area: June through August.

This species is the most abundant Dusky Wing in the area. It is found in fields and coastal margins along the southern borders of Carteret County. It was not taken in any of the inland areas more than three miles from the coast, nor was it collected in forests or savannahs.

The females of the Zarucco Dusky Wing are extremely difficult to distinguish from those of the other species of the genus and until further work is done on the female taxonomic characters, the identification of most of those taken in the Beaufort region will be uncertain.

There were no gaps in the distribution of the species through the season.

Copaeodes minima (Edwards)

State: Gaston County, August 25, 1936; Wilmington, August 29, 1939.

Beaufort area: Late March through November.

The Southern Skipperling was found only in the grassy areas around the Newport River in south central Carteret County. It was primarily collected at the Beaufort airport although the species was taken once on *Borrichia* along the causeway between Morehead City and Beaufort, and once on the west shore

of the Newport River. The species is most abundant during June and August.

A male and female taken in November (the last collection of the species) were considerably darker on the under surfaces than those taken during the rest of the season. The characteristic white line along the median veins of the hindwing was only faintly visible through the suffusion of the darker scales in these forms.

The species has a peculiar habit when at rest of partially spreading the hindwings while the forewings are closed. Its flight is close to the ground, seldom higher than the tops of the grass.

The collection of this skipper in the Beaufort region, as far as the writer can determine, marks the third time it has been recorded in North Carolina and is the northernmost record of a permanent resident population in the eastern United States.

Atrytone ruricola metacomet (Harris)

State: Raleigh, May, June, August; Cranberry, July.

Beaufort area: June and July.

The Dun Skipper is another rare species in the area. All collections of the species were made in woodland clearings, especially in maritime forest communities.

Amblyscirtes carolina (Skinner)

State: Raleigh, Lumberton, Roanoke Rapids, Hamlet, Windsor, Gastonia, March, April, August, and September.

Beaufort area: July and August.

The Carolina Roadside Skipper is rare here even though it is a coastal plain species. Typically found in swamps and marshes, it occurs in this region in damp meadows and savannah "titis".

Lerodea eufala (Edwards)

State: Gastonia, August.

Beaufort area: June, late August through November.

The habitats of this species are open areas such as meadows and coastal grasslands. The Eufala Skipper was taken also at Cape Lookout in September on the grass flats behind the ocean beach sand dunes. It was never common.

The absence of the skipper during July and early August suggests that the species has two broods in this region.

Oligoria maculata (Edwards)

State: Wilmington, August, 1893.

Beaufort area: August and September.

This skipper, the Twin Spot, was taken in two localities, the Beaufort airport and a savannah southeast of Newport. It was visiting fall flowers in both places.

Little is known about its life history, but its range is given as Florida (common) to Georgia, with strays northward (Klots, 1951). It is possible that the occurrence of the species in the Beaufort area represents strays and that the species should not be considered a regular resident here.

The checklist below contains all of the species found during the survey. The species marked by an asterisk (*) represent those previously unreported for Carteret County. Some of them have no special significance other than that they are new records for this county since they have been reported from neighboring counties. Others, as it has been pointed out in the preceding paragraphs, are of importance as range extensions of various distances.

Several collectors, notably Brimley, F. Sherman, Jr., and A. H. Clark, have collected species in the Beaufort region which were not found by the writer. The collections are for single days in various years so that no indication of abundance or duration of the population is known. These species are:

Thorybes pylades
Ancyloxypha numitor
Poanes zabulon
Amblyscirtes textor
Mitoura gryneus
Ascia monuste

With the exception of *Ascia monuste*, these species are widely distributed within the state and may be expected in future collections. *Ascia monuste* was taken by Clark and represents the only record of its occurrence in North Carolina.

A Checklist of the Rhopalocera of Carteret County, N. C.

Euptychia a. areolata (Ab. & Sm.)
Euptychia c. cymela Cramer
Euptychia hermes sosybia (Fabr.)
Cercyonis p. pegala (Fabr.)
**Polygonia interrogationis* (Fabr.)
Vanessa atalanta italica Stichel
**Vanessa cardui carduelis* (Cr.)
Vanessa virginiensis (Dr.)
**Precis lavinia coenia* (Hueb.)
**Limenitis a. archippus* (Cr.)
**Phyciodes phaon* (Edw.)
Phyciodes t. tharos (Dr.)
Euptoieta claudia (Cr.)
Agraulis vanillae nigrior Mich.
**Danaus p. plexippus* (L.)
Danaus gilippus berenice (Cr.)
**Lephelisca virginiensis* (Guerin)
Everes c. comyntas (Godt.)
**Lycaenopsis argiolus pseudargiolus* (B. & L.)
**Atlides halesus* Cr.
Strymon cecrops (Fabr.)
Strymon melinus humuli Har.
Pieris rapae (L.)
Phoebis sennae eubule (L.)
**Colias eurytheme* Bdvl.
**Eurema nicippe* (Cr.)
Eurema l. lisa (B. & L.)
**Papilio philenor* L.
Papilio polyxenes asterius Stoll
Papilio g. glaucus L.
Papilio t. troilus L.
Papilio p. palamedes Dr.
Papilio c. cresphontes Cr.
**Papilio marcellus* Cr.
**Epargyreus clarus* (Cr.)
Urbanus proteus (L.)
**Thorybes bathyllus* (Ab. & Sm.)
**Thorybes confusis* Bell
Pyrgus communis (Gr.)
Pholisora catullus (Fabr.)
Pholisora hayhurstii (Edw.)
**Erynnis horatius* (Sc. & Bur.)
**Erynnis juvenalis* (Fabr.)
**Erynnis zarucco* (Lucas)
**Copaeodes minima* (Edw.)
Hylephila phyleus (Dr.)
Atalopedes campestris (Bdvl.)
**Polites manataaqua* (Sc.)
Polites vibex (B. & L.)
**Wallengrenia otho* (Ab. & Sm.)
**Atrytone l. logan* (Edw.)
**Atrytone ruricola metacomet* (Har.)
**Lerema accius* (Ab. & Sm.)
**Amblyscirtes carolina* (Sk.)
**Lerodea eufala* (Edw.)
Lerodea lherminieri (Latr.)
**Oligoria maculata* (Edw.)
Panoquina ocola (Edw.)
Panoquina panoquin (Sc.)

* Previously unreported for the Beaufort area.

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IDENTIFICATION OF JUVENILE SHRIMP (PENAEIDAE) IN NORTH CAROLINA[1]

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Adult morphological differences are well established and moderately easy to determine among three species of penaeid shrimp (*Penaeus setiferus* (Linn.), *P. duorarum* Burkenroad and *P. aztecus* Ives) which are fished for commercially along the Atlantic and Gulf coasts of the United States (Burkenroad, 1939: 17, 31, 34). Serological evidence supports these specific differences (Leone and Pryor, 1952). However, morphological distinctions among the juveniles of these species are obscure, and of the three species, *P. duorarum* and *P. aztecus* are the most difficult to separate. Specific differences in the external genitalia serve admirably for identifying adolescent or adult shrimp, but for individuals under 50 mm. in total length these differences are not sufficiently developed for easy identification. Widths of grooves on the carapace and certain features in the external genitalia can be used for identification of the young (Burkenroad, 1939: 34, 39), but the use of such characters requires careful scrutiny of minute differences with the aid of a microscope.

During the course of work on the life histories of these species in North Carolina, other specific characters or combinations of characters have been chosen for use in routine identification of large numbers of juvenile shrimp. These characters were found to be accurate and easily observed for nearly all individuals examined. The aim was to use any character that living or recently preserved specimens might show, and not to choose only characters that would be of use in old, faded, preserved material. The characters here proposed will separate either sex for the species in question within the size range of 17 to 50 mm. in total body length. Above 50 mm. body length the juvenile characters can be used in conjunction with adult characters.

In the discussion that follows, the individuals used for the illustrations were taken from within restricted size groups and selection was exercised only in obtaining uninjured specimens. The drawings of rostra and terminal segment appendages were made with the aid of a camera lucida from specimens freshly preserved in formalin. The illustrations of the terminal segment appendages show semidiagrammatic representations of the color patterns. Variations shown within species are individual and do not represent rigid patterns for growth stages.

The rostral characters described and illustrated can be used for identifying either fresh or old faded material, but because of individual variations, reliance on these characters alone must be tempered with judgment.

[1] Contribution No. 34 from the University of North Carolina Institute of Fisheries Research, Morehead City, North Carolina.

FIG. 1. Comparisons of rostrum shapes and sizes in three species of juvenile Penaeidae at selected size stages. All illustrations four times natural size and made with the aid of a camera lucida. Sizes in mm. indicate total body lengths.

The descriptions of color were made in the field from freshly caught specimens with the aid of a hand lens. The coloration of shrimp is commonly known to vary with the environment. Although the three species considered here are no exception to this common occurrence, there is enough consistency in the colors and color patterns of the species to be of great use to the investigator. The juvenile colorations for all three of the species can be broadly stated as follows: (1) the usual or average color as given in the descriptions below; (2) a darker phase (brown, slate-blue or dark gray) which is found in individuals collected in brackish tidal creeks where there is a wealth of forest litter on the bottom, or in individuals which molt infrequently in the colder part of the year; (3) a greener phase which is found in individuals living in beds of green vegetation in shallow water during the warmer months. All manner of variations occur, but by far the most common colors are the first stated.

Penaeus setiferus, the White Shrimp

The cephalothorax has a median dorsal ridge which is continuous with the serrated dorsal ridge of the rostrum. This ridge is not flanked on each side by a groove. The rostrum is prominent; the terminal portion which is toothless dorsally is usually directed straight forward in the 17 mm. size, but it becomes progressively more attenuated and upturned in older individuals (Fig. 1). The number of teeth on the rostrum is variable, but the terminal portion which is smooth dorsally is always long as compared with *P. duorarum* and *P. aztecus*.

The ground color of the body is a clear gray with a scattering of small blue and brown chromatophores which are most abundant dorsolaterally. Laterally on the cephalothorax the blue chromatophores predominate. The uropods are colored distally with reddish-brown to brown chromatophores in individuals over 20 mm. in length (Fig. 2). In individuals 17 mm. long (Fig. 2) this pigmentation is barely distinguishable, but the brown distal portion of the uropods becomes more densely colored with age. The uropods of the larger juveniles possess a narrow dorsal olive-green border distally. (In the adults this border is green or blue.)

Penaeus duorarum, the Spotted Shrimp

The cephalothorax has a median dorsal ridge which is continuous with the serrated dorsal ridge of the rostrum. This ridge is flanked on each side by a groove which is extremely shallow in 17 mm. individuals, but is clearly defined in 20 mm. and older individuals. The rostrum is prominent; the terminal portion which is toothless dorsally is usually directed straight forward, or sometimes slightly upturned (Fig. 1). The number of teeth on the rostrum is variable, and the terminal portion which is smooth dorsally is usually shorter than that of *P. setiferus* or *P. aztecus* (especially in sizes above 35 mm. total length). Viewed laterally the entire rostrum is usually shorter in relation to its depth than in *P. setiferus* or *P. aztecus*.

The ground color of the body is a clear gray with a scattering of predominantly

slate-blue and reddish-brown chromatophores. The chromatophores are concentrated in dark dorsal and lateral transverse bands on the abdominal segments and in a dark lateral patch on the cephalothorax. The most conspicuous lateral band on the abdomen tends to form a distinct spot at the juncture of the third and fourth abdominal segments. The uropods in all body sizes have a nearly uniform scattering of chromatophores which are predominantly reddish-brown distally, but blue along the cuticular creases. The uropods show a uniform degree of transparency throughout. The uropods of the larger juveniles possess a dorsal light blue border distally. (In the adults this border remains blue.)

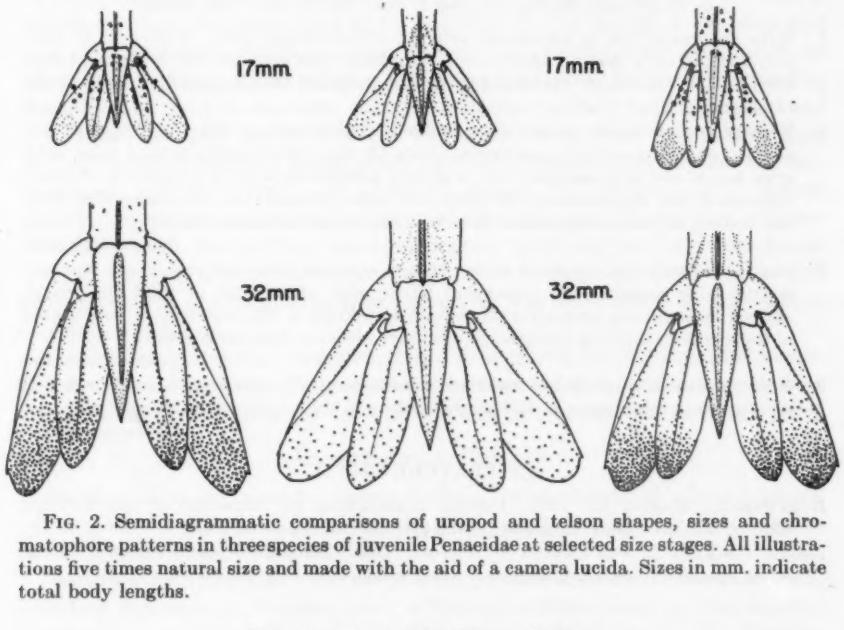

FIG. 2. Semidiagrammatic comparisons of uropod and telson shapes, sizes and chromatophore patterns in three species of juvenile Penaeidae at selected size stages. All illustrations five times natural size and made with the aid of a camera lucida. Sizes in mm. indicate total body lengths.

Penaeus aztecus, the Brown Shrimp

The cephalothorax has a median dorsal ridge which is continuous with the serrated dorsal ridge of the rostrum. This ridge is flanked on each side by a groove which is extremely shallow in 17 mm. individuals, but is clearly defined in 20 mm. and older individuals. The rostrum is prominent; the terminal portion which is toothless dorsally is usually directed straight forward in the 17 mm. size, but becomes progressively more attenuated and upturned in older individuals (Fig. 1). The number of teeth on the rostrum is variable and the terminal portion which is smooth dorsally is intermediate in length between that of *P. setiferus* and *P. duorarum*. Viewed laterally, the entire rostrum becomes

progressively more sinuous with age, and it is usually longer in relation to its depth than the rostrum of *P. duorarum*.

The ground color of the body is a clear gray with a scattering of predominantly brown and olive-green chromatophores. Some chromatophores on the dorsal and lateral surfaces of the abdominal segments are nearly orange. The uropods are colored with reddish-brown to brown chromatophores distally (Fig. 2) in individuals over 20 mm. in length. In individuals 17 mm. long this pigmentation is barely distinguishable (Fig. 2), but the brown distal portion of the uropods becomes more densely colored with age. The uropods of the larger juveniles possess a dorsal green border distally. (In the adults this border remains light green.)

Key to Juvenile Shrimp between 17 mm. and 47 mm. Total Length

A. With grooves lateral to mid-dorsal ridge of cephalothorax (very shallow in 17 mm. individuals); color gray to light brown, sometimes with greenish cast in shrimp taken from beds of vegetation; chromatophores numerous and closely spaced, often in bands or patches.....B

A_1. Without grooves lateral to mid-dorsal ridge of cephalothorax; rostrum prominent and slightly upturned at tip in specimens above 22 mm. total length; ground color light gray, sometimes with greenish cast in shrimp taken from beds of vegetation; chromatophores widely spaced except on spines and ridges; chromatophores colored slate-blue and brown; uropods with reddish-brown to brown colored areas distally.....
Penaeus setiferus.

B. Rostrum usually not upturned at tip; chromatophores slate-blue and brown in color; usually with conspicuously pigmented lateral spot at juncture of third and fourth abdominal segments; uropods with uniform sprinkling of chromatophores, but degree of transparency uniform throughout (color more dense in older individuals).....
Penaeus duorarum.

B_1. Rostrum usually slightly upturned and attenuate at tip; chromatophores brown and olive-green in color; uropods with reddish-brown to brown colored areas distally.....
Penaeus aztecus.

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A STRAIN OF TOBACCO MOSAIC VIRUS INDUCING SYSTEMIC NECROSIS IN FLUE-CURED TOBACCO[1]

By W. A. Jenkins, D. G. Sharp, and F. A. Wolf[2]

During the mid-harvest seasons of 1951 and 1952 our attention was directed to a disease which we had never previously encountered, occurring scatteringly in a two-acre field of Virginia Gold tobacco near Chatham, Virginia. In both seasons, precocity of maturity was the outstanding feature first noted, some plants having been harvested completely, and others, depending upon severity of attack, exhibiting varying stages of prematurity. Closer inspection of plants showing such premature ripening revealed the presence of necrotic streaks extending along the stems, frequently coursing the full length of the stem and into the root system. Similarly, there were necrotic lesions in the laminae of the leaves and necrosis of the midribs and secondary veins, frequently extending along the petioles into the stem. In many instances, axillary buds were dead and dry. When affected stems were cut lengthwise there were found darkened, necrotic areas of the pith immediately beneath and extending beyond sunken, blackened, cortical streaks. In advanced stages, the blackened pith tissues consisted of numerous discrete or coalesced necrotic areas of concentric appearance. Moreover, the cambial tissues of petiole, stem, and root were blackened (Fig. 1). On some affected plants, the symptom-complex was complicated by the superimposition of common tobacco mosaic, as was determined by subsequent inoculation trials.

The following account, therefore, deals with efforts to diagnose this disease and to identify its cause. These studies involve isolation trials, inoculations, examinations of expressed sap with an electron microscope and serologic tests.

Experimental Results

Isolation attempts: Necrotic tissues from different organs of affected plants were repeatedly plated out on potato-dextrose agar but no recognizable fungous or bacterial pathogens were isolated.

Inoculations: Numerous varieties of tobacco were used in inoculation trials, including Samsoun (a Turkish type), a hybrid between Samsoun and Burley, Burley 16, Lizzard Tail Orinoco (a dark-fired type), Dixie Bright 101, Virginia Gold, and several other flue-cured types carrying the glutinosa factor for resistance to tobacco mosaic virus (TMV). In addition, repeated inoculation trials were made on White Wonder cucumber, June Pink tomato, and Tendergreen string beans.

Young Samsoun tobacco plants and those of a Burley-Samsoun hybrid, approximately 60 cm. tall, were inoculated during September by inserting

[1] Cooperative investigation between the Virginia Agricultural Experiment Station and Duke University.

[2] We are grateful for the help given by Dr. W. C. Price, University of Pittsburgh, Pittsburgh, Pa., and Dr. Roy Markham, Molteno Institute, Cambridge, England.

diseased pith tissues into their stems. Within a week, prominent necrotic streaks had begun to appear both above and below the sites of insertion of inoculum. Several of the inoculated plants died within five weeks with symptoms like those of field material. Other inoculations were made by wiping leaves with a swab moistened in expressed sap from necrotic pith or by rubbing the leaves between the fingers previously moistened with such sap. Initial symptoms appeared as yellow flecks after 36 hours at the sites of inoculation, and these flecks were transformed into necrotic (local) lesions 0.5–1.0 cm. in diameter after 3–4 days. Soon thereafter, the leaves with abundant lesions became flaccid and yellowed prematurely.

Leaves, sucker growth, pith, and roots collected from the field and kept frozen for periods ranging from 6 to 12 weeks were also used as inoculum on several tobacco varieties, including Virginia Gold, Lizzard Tail Orinoco, and a number of lines carrying the glutinosa factor, as well as cucumber and beans. Watery suspensions of macerated tissues were applied to young leaves of rapidly growing potted plants by the wipe method.

On Virginia Gold, the immature leaves near the bud exhibited faint mottling two weeks after inoculation but there was neither blistering nor leaf distortion as commonly occurs with TMV. After an additional interval of 4 weeks, severe necrosis of the veins and midrib developed on certain plants and the streaks extended into the stem by way of the petiole. Concurrently, necrotic flecks ranging in size from pin-point to 1.0 cm. appeared on leaves at all levels. Similar responses to inoculation were elicited in the varieties Dixie Bright 101, Gold Dollar, and Oxford 402.

On Lizzard Tail Orinoco delayed local lesions, few in number but larger, were developed 4 days after inoculation. This symptom expression was followed 10 days later by severe rimbinding, stunting, and distortion of the expanding bud leaves.

All tobacco varieties carrying the glutinosa factor reacted alike to inoculation. Abundant local lesions appeared after 48–72 hours but the number of lesions was comparatively smaller than was obtained with comparative trials using TMV as inoculum. In addition, there was no evidence that infection became systemic with the virus in question, whereas a high percentage of infections with TMV became systemic under the same conditions. Failure to obtain systemic infections also followed introduction of inoculum into midribs of young leaves and insertion of inoculum into cut or broken surfaces of freshly topped plants. With the latter method, however, a few trials produced necrotic reactions which extended for a few centimeters below the locus of inoculation.

On cucumber, the first evidence of infection was faint clearing of the veins on young leaves, followed by progressive shortening of internodes, resulting, finally, in pronounced stunting. The flowers remained asymptomatic.

String beans developed no recognizable symptoms following inoculation.

On tomatoes, a distinct mosaic pattern developed on young leaves 10–14 days after inoculation. The pattern was accompanied by and sometimes preceded by pronounced curling of young leaflets and thus resembled one of the symptoms

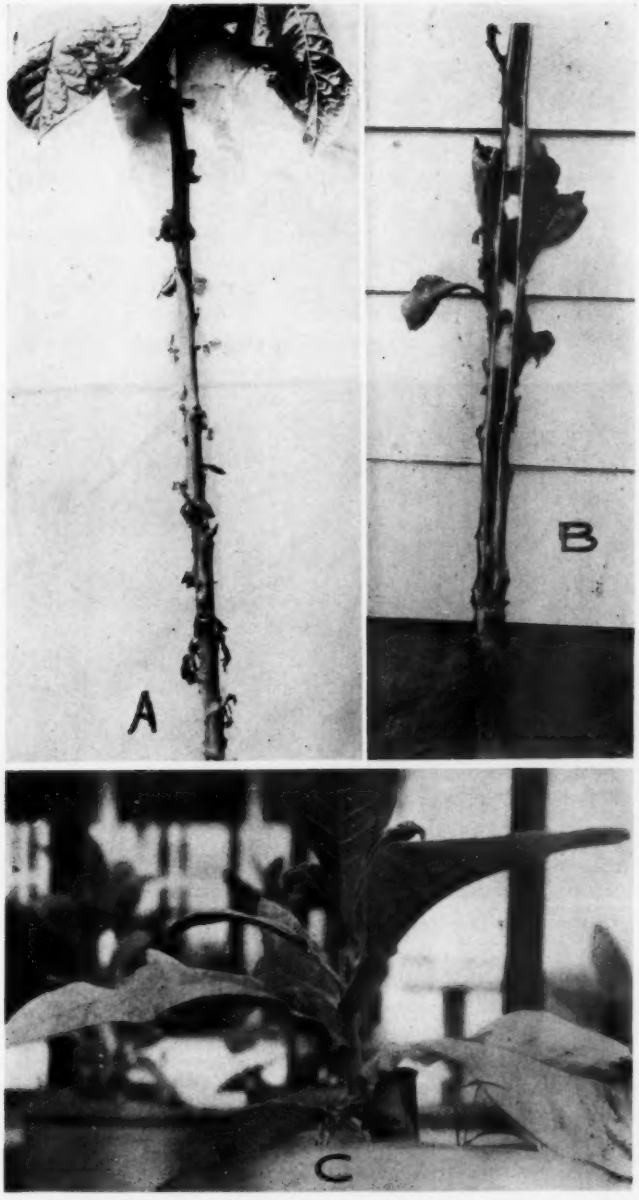

FIG. 1. A. Prematurely ripened tobacco plant, systemically infected, from the field. External streaks and blackened buds apparent.

B. Necrosis of cambium and pith tissues as exhibited after splitting the stem.

C. Artificially inoculated Virginia Gold plant. Bud leaves are distorted and necrotic areas appear on the stem.

of tobacco mosaic. No other symptoms developed and after a time the plants appeared to have recovered completely.

Since Holmes (5) and Valleau and Johnson (15) have shown that certain species of *Plantago* serve as reservoirs for a virus capable of inducing necrosis in tobacco, several attempts were made to infect tobacco with sap from *Plantago lanceolata* L. collected on the border of the tobacco field from which diseased tobacco had been first collected. All such attempts were unsuccessful. When sap from the necrotic pith of diseased tobacco plants was used as inoculum on *Plantago lanceolata*, however, abundant local lesions were produced after 10–14 days. When, in turn, sap from such infected *Plantago* leaves was swabbed upon the surface of Virginia Gold tobacco leaves, after 36 hours faint yellow flecks

FIG. 2. Electron micrograph of a necrosis-inducing virus from tobacco. ×33,000.

appeared, which developed within two to three more days, into well-defined, necrotic lesions bordered by greenish-yellow tissue.

Electron Microscopy: In preparing material for examination with the electron microscope, use was made of artificially inoculated tobacco plants which exhibited no symptoms of ordinary mosaic. Diseased young plants were first ground in a meat chopper. The sap from the ground material was pressed out by hand through several thicknesses of cheese-cloth. This fluid was next partially clarified by addition of celite before it was passed through filter paper in a Buchner funnel. A water pump provided the necessary suction. The clarified sap was then ultra-centrifuged at 47,000 g. for an hour, followed by re-suspension of the precipitate in 0.06 M phosphate buffer (pH 7.2) sufficient in amount to bring the suspension back to its original volume. This suspension was centrifuged at 3,000 g. for 10

minutes and the pellet discarded. The supernate, however, was ultracentrifuged again at 47,000 g. for an hour. Examinations were made of 1:100 dilutions of suspensions of the pellets from the first and second ultracentrifugations. Each dilute suspension was deposited on a collodion film on an appropriate screen and was chromium-shadowcast at an angle of 15°. A micrograph of a representative field, as seen by the electron microscope is shown in fig. 2. The virus, present in abundance, is manifestly of the shape and size of common TMV.

A portion of the purified virus, when used as inoculum, induced the necrotic disease. Further evidence of relationship was sought through serologic tests.

TABLE 1

*Titration of TMV antiserum against TMV**

DILUTIONS ANTISERUM	TMV ANTIGEN DILUTIONS							ANTISERUM CONTROL
	1/256	1/512	1/1024	1/2048	1/4096	1/8192	1/16384	
1/64	++	+++	+++	++++	++++	+++	+−	−
1/128	tr.	+	+++	++++	++++	+++	+−	−
1/256	−	−	tr.	+	+	++	tr.	−
1/512	−	−	−	−	tr.	−	−	−
Antigen control	−	−	−	−	−	−	−	

* Only ++++ reactions are significant, but weaker reactions are to be regarded as valuable guides, in both tables.

TABLE 2

*Titration of TMV antiserum against Chatham virus**

DILUTIONS ANTISERUM	1/64	1/128	1/256	1/512	1/1024	1/2048	1/4096	ANTISERUM CONTROL
1/4	++++	++++	++++	++++	++	+	+	−
1/8	++++	++++	+++	++	+−	+−	−	−
1/16	+	+	+−	tr.	−	−	−	−
1/32	−	−	−	−	−	−	−	−
Antigen control	−	−	−	−	−	−	−	

* See footnote to table 1.

Serologic Findings: Other portions of the purified virus were sent to Dr. W. C. Price, and to Dr. Roy Markham, each of whom performed complement-fixation tests using previously prepared antisera against TMV. Conclusions from their tests are in accord but for purposes of interpretation and clarification a protocol as prepared by Dr. Price is included here in tables 1 and 2.

As may be seen from the tables, the Chatham virus, as antigen, reacted with TMV antiserum at a 1:512 dilution of antigen and 1:4 dilution of antiserum. The end point of Chatham antigen approximates a dilution of 1:128 and that of antiserum 1:8; thus indicating a 16-fold difference. Such a difference is clearly significant in differentiating the two antigens, but at the same time the cross reaction shows genetic relationship between the two viruses.

Proteins have been found to be among the chemical constituents of which viruses, whether from animal or plant tissues, are composed. The TMV is among the few plant viruses which have been obtained in crystalline form (8). Ross (12) determined that TMV contains 3.9% tyrosine, 4.5% tryptophane, 4.7% proline, 9.0% arginine, 6.7% phenylalanine, 6.4% serine, and 5.3% threonine. Our analyses involving the proteinaceous nature of the virus under consideration consist of determinations of total nitrogen in the pellets obtained after two ultracentrifugations of 20 cm. of sap from necrotic tissue as compared with an equal quantity from normal tobacco tissue. The necrotic tissue was found to contain 0.573 mg. total nitrogen and normal tissue 0.098 mg., which difference may be presumed to be accounted for largely by the proteins of the virus itself.

DISCUSSION

Recent investigations, as typified by those dealing with ringspot virus of tobacco and TMV have shown that the host range of a virus may include quite unrelated species. The ringspot virus, for example, has been shown to attack soybeans (2), watermelon (10), eggplant (16), and bean (9); while ringspot symptoms have been produced on tobacco from inoculum taken from gladiolus (3) and from the American elm (18).

To determine whether the necrotic virus disease under consideration is identical with previously described tobacco diseases presents obvious difficulties. Certainly it is not to be confused with a disease noted in Australia by Smith and Bald (13), a disorder for which virologists have accepted the name "necrosis virus disease". Its causal agency, they found, is a spherical virus ranging in size from 20–30 mμ.

Certain entities in the TMV complex are found to resemble each other in size and shape and have been regarded as strains. Holmes (5) regarded the rod-shaped virus which he isolated from *Plantago major* L. and from *P. lanceolata* L. as a distinct strain of TMV. Doolittle and Beecher (4) found that the sap from tomato leaves exhibiting necrosis and shrivelling would induce the syndrome of common mosaic if inoculated into tobacco leaves. This, also, was regarded as a distinct strain of TMV. Valleau and Johnson (15) noted stem and leaf necrosis among plants in a field of Burley tobacco in Kentucky and determined, by means of inoculations, that *Plantago* growing in the seed beds and near them constituted the reservoir for the virus. By inoculating different varieties of tobacco with sap expressed from *Plantago*, they induced necrosis in certain varieties and typical leaf mottling and distortion in others. On the basis of host reaction, the former group was designated as N′N′ varieties and the latter group as n′n′ varieties. Complete confirmation of these results was obtained in subsequent inoculation trials (17). Ainsworth (1) identified the agency causing enations on tomato as being of the tobacco virus type. Price and Fenne (10) found that the virus responsible for a rosette disease of tomatoes in Virginia may induce mosaic of tobacco. As inoculum, Stover (14) used sap from certain varieties of tobacco exhibiting vascular necrosis and wilting in Ontario Province. By inoculation of several different varieties of tobacco, he determined that some

became necrotic, i.e., were N′N′ varieties, whereas others exhibited leaf mottling, stunting, and distortion characteristic of the response in n′n′ varieties. Stover kindly sent us dried leaves from his diseased plants, collected in 1950. Inoculum obtained by suspension of these dried leaves, macerated in water, induced infections on tobacco leaves and stems 28 months after collection by Stover and resulted in symptoms very similar to if not identical with our disease.

Attention may also be called to the fact that in the foregoing studies, including the one herein being reported, the causal viruses have been repeatedly transferred from plant to plant in the greenhouse and in the laboratory and that they have maintained their ability to produce the syndrome characteristic of each disease The viruses must, therefore, possess a high degree of stability. Variations and mutations among viruses, however, are being noted continually by students of viruses. The mechanisms responsible for such behavior are not understood, but are presumably essentially like those of analagous processes among plants and animals.

Coincident with the phenomenon of mutation of viruses, one should also consider the probability of survival of aberrant forms as fostered by differences in tobacco varieties. New varieties produced by tobacco breeding are known to yield genetic combinations not hitherto existing. Such host differences might provide a basis for symptom expressions not heretofore encountered. However, until mutations among viruses can be produced at will, it does not appear profitable to speculate on the problem of origin of strain differences. One is inclined rather to conclude, as did Valleau and Johnson (15) that a single type strain of TMV does not exist but instead TMV must be regarded as a multiplicity of strains.

There remains to be considered the probability that the disease under consideration is identical with Rotterdam-B disease described from Sumatra by Jochems (6, 7). It has never been established that this disease occurs outside Sumatra, although it was suggested by Wolf (19) that apparently a similar disease has been noted on cigar tobacco in Germany, Ontario, Connecticut, and Wisconsin. Jochems noted that this disease is scatteringly present throughout the fields affected, that young leaves become mottled, that indefinite margined, yellowish-green areas are initially produced which later change to angular, necrotic spots about 5 mm. in diameter, that affected bud leaves become flaccid, crumpled and distorted, that midribs and veins become necrotic, and finally, that necrotic areas involving the stem, pith, and cortex appear and the affected plants eventually die. Our observations on inoculations in the greenhouse, as regards percentage of systemic infections obtained, cause us to consider that it is the presence of systemically diseased plants which gives the impression that the disease in the field occurs scatteringly. The symptom-complex of the Rotterdam-B disease thus accords well with the one from Chatham, Virginia, but for obvious reasons complete proof must remain lacking. As further evidence of the possible identity of the two diseases, it may be pointed out that both *Plantago lanceolata* L. and *P. major* L. are indigenous to the Indonesian flora.[3]

[3] Information obtained from personal communication with Walter H. Hodge, Division of Plant Exploration, U.S.D.A. Beltsville, Md.

Plantago in Sumatra should therefore be tested as a possible reservoir for Rotterdam-B virus.

CONTROL

The results of these studies indicate that the disease in question may be adequately controlled by the use of tobacco varieties carrying the glutinosa factor for resistance to TMV or by the usual sanitation practices which are well known for the control of common mosaic of tobacco. Attention might well be directed also to the eradication of *Plantago* from seed-bed sites and from borders of tobacco fields.

SUMMARY

During two consecutive seasons, 1951 and 1952, a destructive virus disease of flue-cured tobacco appeared in the vicinity of Chatham, Virginia. The disease causes necrotic lesions in the leaf lamina, blackening and killing of sucker growth and terminal buds, necrosis of the midribs and veins which may extend progressively through the cambium tissues of the petiole, stem, and roots of the plant, and necrosis in the pith when the infection develops systemically. A striking aspect of the disease is precocity of maturity of plants, systemically infected ones exhibiting extreme premature ripening of leaves. The disease was first noted on the variety Virginia Gold, and subsequent inoculation studies with numerous other varieties indicate that none suffers such severe symptoms as does this variety.

Inoculation studies indicate that the virus may involve a number of different varieties of tobacco, including Turkish and dark-fired types, causing mottling of leaves, local lesion reactions, or mild necrosis, apparently depending on the genetic composition of the variety under test.

Electron micrographs as well as complement fixation tests indicate that the virus is probably a strain of TMV.

The probability exists that this disease may be quite like one described by Stover, the Rotterdam-B disease reported from Sumatra, and those having *Plantago* as a reservoir.

There are indications that the disease may be controlled by planting varieties carrying the glutinosa factor or by sanitation procedures used for the control of common mosaic of tobacco.

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ACID PHOSPHATASE DISTRIBUTION PATTERNS IN THE DEVELOPING EMBRYO OF *COCOS NUCIFERA*

By Katherine S. Wilson[1] and Victor M. Cutter Jr.[2]

Plates 1–2

During previous studies which we have carried out upon the developing tissues of the fruits of *Cocos* (Cutter, Wilson and Dubé 1952) and upon the nuclear and cellular behavior in the developing endosperm (Cutter and Wilson 1953) we have had occasion to consider the distribution of acid phosphatases in these tissues during various developmental stages. Quantitative determinations carried out with colorimetric methods demonstrated marked differences in acid phosphatase activity among various tissues of the fruit and in specific tissues at different stages in their development (Wilson and Cutter 1952). Histochemical studies on the same tissues confirmed these patterns and demonstrated the specific cellular distribution of these enzymes (Wilson and Cutter 1953). Many embryos of *Cocos* in various stages were available as a by product of these investigations and these provided an excellent opportunity for a study of the distribution patterns of acid phosphatase here. The large size of the *Cocos* embryo and the ease with which it may be excised from the fruit makes it ideal for such a study.

Methods

The younger embryos used in this study were obtained from coconuts shipped from Miami, Florida, under refrigeration. The older embryos were excised from coconuts purchased in stores in the New Haven, Conn. area and were of undetermined age and origin, but were of comparable size and were viable. All embryos were killed and fixed in 80 per cent ethyl alcohol at 4°C. Dehydration, clearing and embedding were carried out as rapidly as possible to minimize loss of enzyme activity. Low melting point paraffin (55°C) was used for embedding and, following sectioning, the mounted sections were stored at 4°C. until tested for enzyme activity. The procedure of Gomori as described by Glick and Fischer (1945) was used for the demonstration of acid phosphatase activity. This involves incubation of the tissue slices in a suitable substrate in the presence of lead ions. Lead phosphate is precipitated at the site of enzyme activity and is subsequently converted to the brown or black sulphide with ammonium sulphide. In our experiments sodium glycerophosphate was provided as the substrate at a level of 21 per cent and all sections were incubated for 16 hours at 37°C. at pH 5. After treatment with ammonium sulphide the sections were counterstained with 1 per cent aqueous fast green, carried through a graded

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series of alcohols, cleared in xylene and mounted in neutral canada balsam. To distinguish between enzymatically liberated phosphate and residual or inorganic phosphate, already present in the tissues, control sections of each stage were treated in exactly the same fashion except that sodium glycerophosphate was omitted from the incubation mixture. Any precipitate developing in the control lots indicated the presence of residual phosphate at that site.

RESULTS

The nucellus is the site of considerable enzyme activity and within the integuments phosphatase appears concentrated in the vascularized areas. Figures 1–3 indicate that there is a marked delimitation of enzyme activity at the interface between integuments and endocarp. There is a very characteristic distribution of phosphatase in the vicinity of the micropyle (fig. 3). In the extension of the nucellus into the micropyle where the embryo is seated there is a sharply defined area in which phosphatase is active. The tissues bordering the micropyle (fig. 3) are practically devoid of activity although there is an accumulation of residual phosphate at this site (fig. 2). A similar situation has been encountered in cucurbit fruits by Wilson (1949).

In the earliest embryonic stages which we have examined (figs. 4–9) phosphatase activity is localized in the cells at the free end of the embryo. The basal end of the embryo which is appressed to the nucellus seems relatively inactive. The large cell at the base of the embryo seen in figures 4, 7 and 8 is probably a persistent synergid. It too is apparently devoid of phosphatase activity. As will be noted in figures 6, 7, 8 and 9, which are serial sections of the same embryo, the tangential section (fig. 7) showing the epidermal area indicates high activity here. There is also phosphatase activity in the nuclei of many of the embryonic cells (fig. 5, 8, 9). It must be realized that in these early stages the embryo is suspended in liquid endosperm or milk, and the cells at the free end which show high activity represent the primordium of the cotyledon, or so-called haustorium, which is reputed to function in the ultimate digestion of the endosperm.

At a slightly later stage (figs. 10, 11), where the solid endosperm is beginning to accumulate around the embryo, phosphatase activity is still abundant in the free end of the embryo, but at this stage there is relatively little phosphatase in the young cellular endosperm. We have previously pointed out a similiar situation in the areas of the developing endosperm away from the embryo attachment site (Wilson and Cutter, 1953). As the solid endosperm increases in thickness and ensheaths the embryo (figs. 12, 13) phosphatase activity becomes very noticeable in the endosperm adjacent to the embryo. Probably this is correlated with the incipient digestion of these cells.

As the differentiation of the embryo proceeds (figs. 14, 15) the endosperm is digested away from the embryo and phosphatase is again seen in the band of digested cells seen around the embryo (fig. 15). With formation of the root and shoot primorida there is phosphatase activity in the coleoptile and in the vascular traces of the coleorhiza. The developing cotyledon also shows areas of enzyme activity. By this stage the stone cells of the endocarp are differentiated and

will be seen to have considerable residual phosphate localized in them (figs. 14, 15). The nucellus and overlying integuments are now either crushed or undergoing digestion.

From this stage onward the cotyledon or haustorium of the embryo enlarges rapidly and elongates in a radial direction toward the center of the embryo sac. As it grows it digests its way through the solid endosperm surrounding it until the embryo comes to lie free in a cavity of the endosperm. During this cotyledonary enlargement the root and shoot are developing very slowly with little increase in size. In a coconut in which the solid endosperm has reached its maximum development, and is approximately 1.5–3 cm. in thickness, the embryo (fig. 18) will be approximately 1 cm. in length. Figures 19–24 illustrate that at this time phosphatase activity is concentrated in the shoot and root primordia, in the vascular system of the developing cotyledon and in the epidermal regions of the embryo. Within the primordia phosphatase activity follows the developing vascular traces and is particularly concentrated in the regions of greatest meristematic development.

Quantitative determinations carried out earlier on the outer and inner portions of the mature cotyledon, which finally fills the entire embryo sac and is appressed to the solid endosperm, indicated that phosphatase was concentrated in the outer layers of this structure. It is obvious that these cells have a primarily digestive function. Early evidence of this localization is seen in figures 19 and 22 where activity is concentrated in the outer layers of the cotyledon.

Figures 25–30 illustrate the transverse pattern of enzyme distribution at three levels in an embryo comparable to that shown in figure 19. At the level of the shoot primordium highest activity appears in the epidermal areas (figs. 25, 26) whereas through the root primordium maximum activity resides in the undifferentiated tissue surrounding the vascular supply to the cotyledon (figs. 27, 28). In figure 25, which is a control section through the shoot primordium, the thin line of cells below the epidermis which appears to contain residual phosphate is actually filled with large pigmented crystals of undetermined composition. There is much residual phosphate in the vascular traces of the cotyledons (fig. 27). Toward the tip of the cotyledon the distribution pattern appears reversed and activity is concentrated within the vascular cylinder and in the epidermal areas (fig. 30). The residual phosphate seen in the vascular traces is probably correlated with the translocation function in these tissues (fig. 29).

There has been some speculation concerning the reliability of this technique for the localization of acid phosphatase activity (Novikoff, 1951). Figures 16–17, which represent serial sections of embryos at two developmental stages, are included to show that there is very close agreement in the pattern of enzyme activity in adjacent sections. The reproducibility of this test is also borne out by the fact that in our experiments all embryos of comparable age showed identical patterns of enzyme distribution. We feel that under proper conditions and with reasonable care in handling of sections an accurate picture of the distribution of this enzyme in plant tissues may be assured. There is, however, little question that the manipulations attendant upon the preparation of sections

involves a certain overall loss and inactivation of enzyme. Therefore the results presented here must be considered as relative, and in no sense quantitative.

SUMMARY

The nucellus and integuments in the vicinity of the micropyle show characteristic patterns of acid phosphatase activity. No activity is seen in the cells filling the micropylar cavity.

Prior to the formation of solid endosperm the young embryos show localization of this enzyme in the cotyledonary primordium and the epidermal areas.

Maturing embryos embedded in solid endosperm show activity in the areas of vascularization and meristematic activity as well as in the epidermal areas.

The solid endosperm surrounding young embryos shows little activity but as digestion of these endosperm cells proceeds phosphatase becomes apparent in them.

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EXPLANATION OF PLATES

PLATE 1

Fig. 1. Radial section through nucellus and integuments in region adjacent to the micropyle of *Cocos* prior to the formation of solid endosperm showing acid phosphatase distribution. ×80.

Fig. 2–3. Control and test sections through nucellus, integuments and endocarp in micropylar region showing embryo *in situ*. Note residual phosphate in micropyle and sharp delimitation of enzyme activity at border between endocarp and integuments. ×60.

Fig. 4. Radial section through embryo seen in Fig. 3, showing high phosphatase activity in free end of embryo. ×830.

Fig. 5. Tangential section through embryo of comparable age to Fig. 4 showing localization of enzyme in the micropylar plug. ×160.

Fig. 6–9. Control and test serial sections through single embryo. ×160.

Fig. 10–11. Control and test tangential sections through free end of embryo as solid endosperm begins to form. ×160.

Fig. 12–13. Control and test tangential sections through embryo embedded in young solid endosperm. Note phosphatase activity where endosperm is being digested. ×80.

Fig. 14–15. Radial section of differentiating embryo 1.5 mm. long. Note phosphatase activity in coleoptile and cotyledonary areas and in the digested endosperm surrounding embryo. ×15.

Fig. 16–17. Serial sections through embryos of different ages to show similarity of phosphatase distribution patterns in adjoining sections. Fig. 16, ×8.3; Fig. 17, ×1.5.

Fig. 18. Embryo 1 cm. long excised from mature coconut, oriented with cotyledon downward as in the fruit. Control and test sections of this stage shown in figs. 19–30.

PLATE 2

Fig. 19. Radial section through embryo 1 cm. long showing enzyme activity in vascularized and meristematic areas and in the epidermal regions of the cotyledon. ×4.5.

Fig. 20–21. Control and test sections through root primordium of embryo shown in preceding figure. ×18.

Fig. 22. Tangential section through same embryo showing shoot primordium. ×4.5.

Fig. 23–24. Control and test sections through shoot primordium of same embryo. ×18.

Fig. 25–26. Control and test transverse sections through embryo of comparable size to the preceding, showing phosphatase distribution in area of the shoot primordium. ×5.

Fig. 27–28. Control and test transverse sections through same embryo in area of root primordium, note residual phosphate in vascular bundles. ×6.7.

Fig. 29–30. Control and test transverse sections through terminal portion of the cotyledon of the same embryo. ×6.7.

PLATE 1

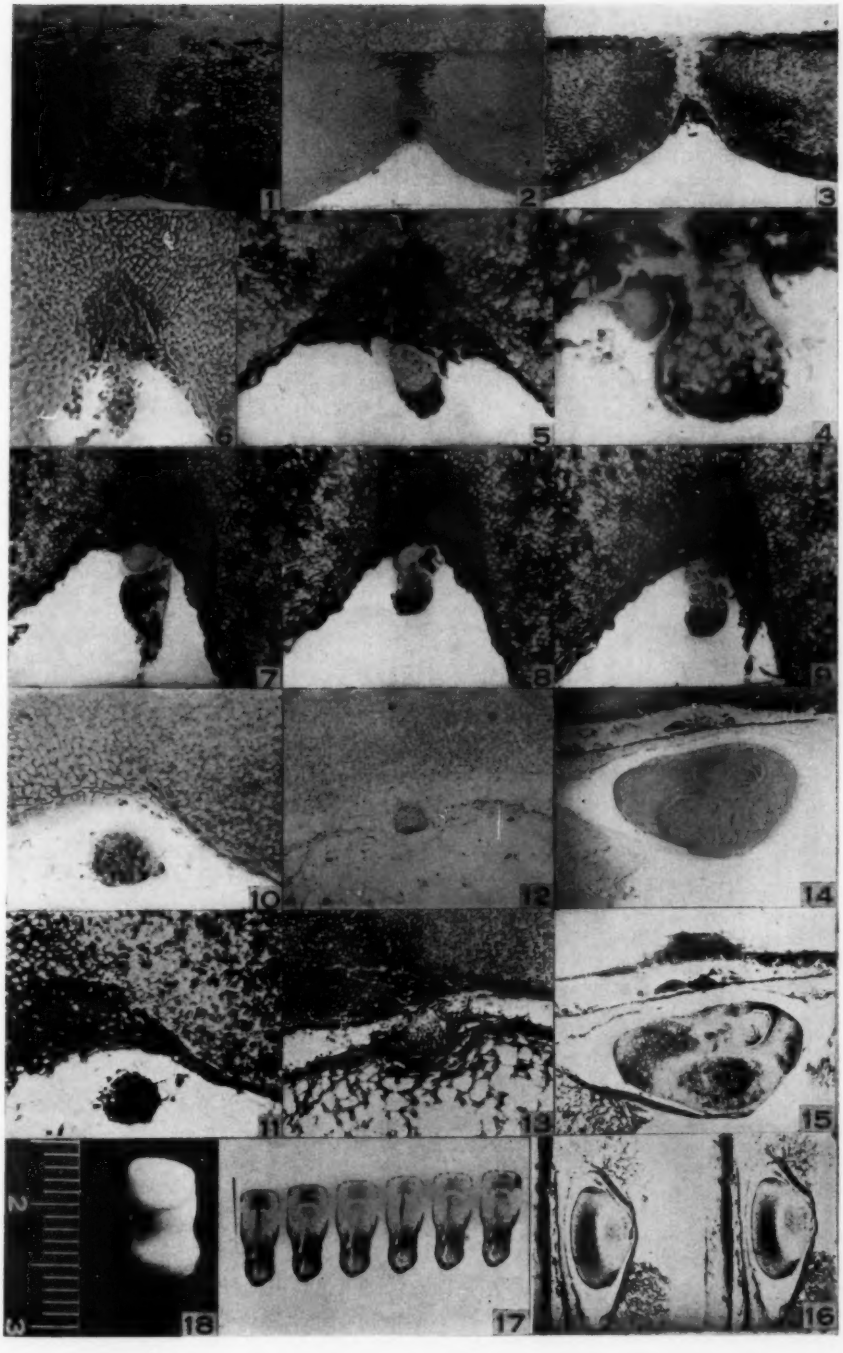
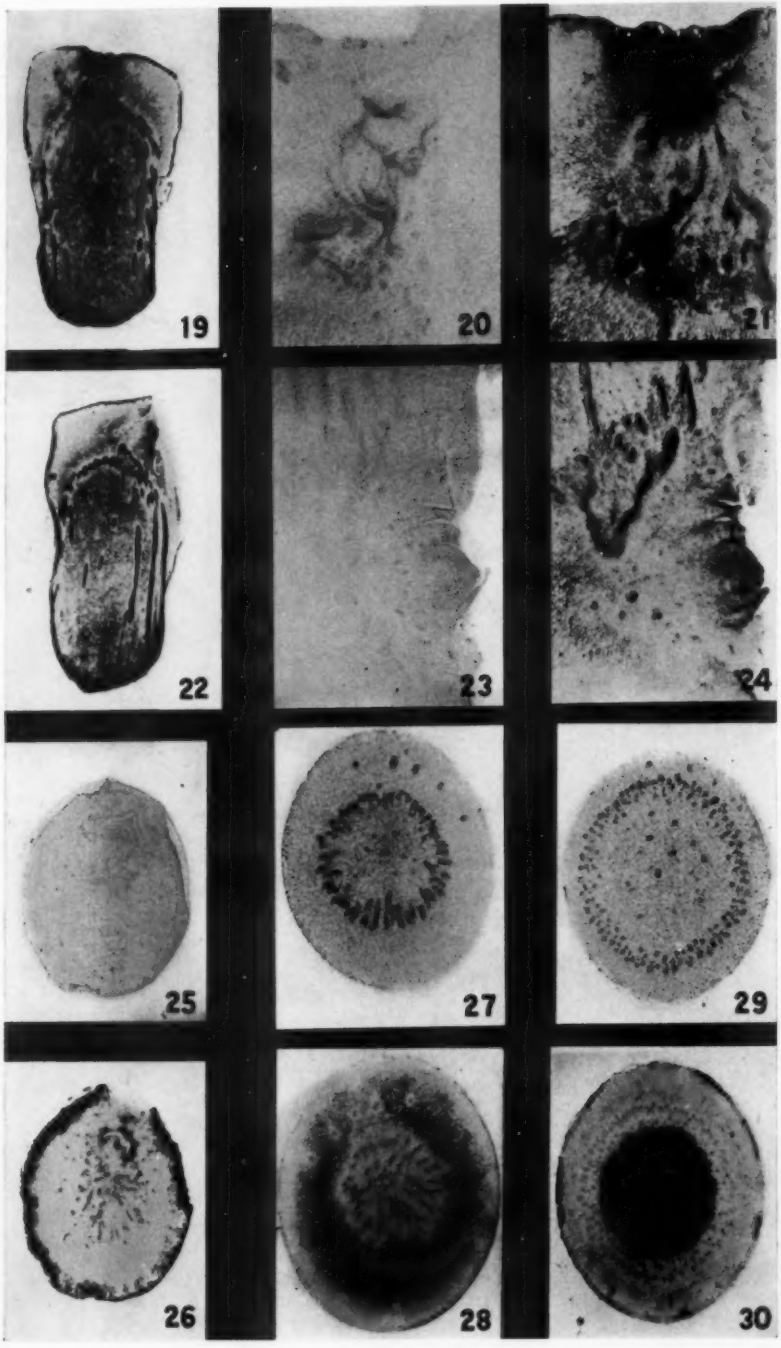


PLATE 2



SOME EFFECTS OF MALEIC HYDRAZIDE ON THE GROWTH OF AVENA SEEDLINGS*

By Sidney P. Johnson and Victor A. Greulach

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Introduction

It is now well established through the work of Greulach and Atchison (1950), Darlington and McLeish (1951), Deysson and Rollen (1951), and others that maleic hydrazide (MH) inhibits cell division, but there is little information on the effect of MH on cell elongation. Since Tetley and Priestley (1927) and Avery and Burkholder (1936) have shown that *Avena* coleoptiles up to a length of 10 mm. grow both by cell division and cell elongation while coleoptiles longer than 10 mm. grow almost entirely by cell elongation alone it would appear that the *Avena* coleoptile would provide favorable material for the study of the effect of MH on cell elongation. Little work has been done on the effect of MH on the growth of *Avena* coleoptiles, or the seedlings in general. In their investigation of the anti-auxin properties of MH Klein and Leopold (1950) employed the *Avena* straight growth test as well as the slit-pea test, but their later more extensive work (Leopold and Klein, 1951, 1952) was done with the pea tests.

In the present study attention was centered on the effect of MH on the growth of the *Avena* coleoptile, with special reference to the cell elongation problem, but the effect of MH on growth of the seedling roots and some MH —indole-3-acetic acid interactions were also investigated. Since observations by the writers supported the suggestion by Naylor and Davis (1950) that certain MH symptoms resemble mineral deficiency symptoms, interactions between selected mineral salts and MH were also studied.

Methods

The glumes were removed from grains of *Avena sativa* var. Victory (var. Columbia being used in a few of the replications), and the grains were then sterilized in a formaldehyde solution. After washing and soaking the grains two hours they were placed groove down on wet filter paper in large covered finger bowls and allowed to germinate. Mesocotyl growth was inhibited by red light cut off at 6440 Å by a Corning filter No. 2030, this wave length being well above the effective phototropic range.

For the first two experiments seedlings of suitable size were then transferred to long strips of galvanized steel with holes of suitable size to permit the roots to project through the strips into the water in a shallow lacquered metal pan on which the metal strips were supported. Each strip accommodated 20 seedlings,

* This paper is a complete revision and condensation by the co-author of part of a master's thesis prepared under his direction by the author (Johnson, 1952) at the University of North Carolina.

the seedlings being held in position (and kept from direct contact with the metal) by means of an inert, pliable plastic called "Morelite." This type of holder permitted easy handling and culture of large numbers of seedlings in a limited space. In the first experiment 500, 1000, and 2000 p.p.m. of the diethanolamine salt of maleic hydrazide in hydrous lanolin were applied to intact coleoptiles (a) apically to coleoptiles 20 to 30 mm. long, (b) apically to coleoptiles about 5 mm. long, (c) unilaterally to coleoptiles 20 to 30 mm. long, and (d) unilaterally to coleoptiles about 5 mm. long. Controls in each series were treated with plain lanolin. In the second experiment coleoptiles about 15 mm. long were decapitated and after 40 mins. were again decapitated, after which 2000 p.p.m. MH in lanolin was applied to the cut surface, plain lanolin being applied to the controls. One rack of seedlings was placed in a horizontal position in the dark and a second was exposed to unilateral light from a 100 watt incandescent bulb 75 cm. distant, a rack of controls also being placed in each situation.

In the third experiment all but the basal 5 mm. of 15 mm. long coleoptiles was decapitated and the seedlings were then placed in petri dishes on 2% agar, 3 mg/l IAA, and 20 g/l sucrose. In one series 1000 p.p.m. MH in lanolin was applied to the coleoptile stump and in a second series 1000 p.p.m. MH was added to the agar. Measurements were made at treatment and after 10 hours at 27°C to determine the effect of MH on root growth.

The *Avena* straight growth test was employed in experiments 4–6, with a 20 hour growth period at 26°C in the following basic solution: 20 g/l sucrose, 3 mg/l IAA, and 1 g/l MH, the MH being omitted in the controls. In experiment 5 the IAA concentration was varied and in experiment 6 various concentrations of $Fe_2(SO_4)_3$, $Ca(NO_3)_2$, H_3BO_3, and thiamin were added to the basic solution (Table II). The 5 mm. sections were cut from coleoptiles 20 to 30 mm. long, except in one series in experiment 4, in which coleoptiles 7–9 mm. long were used.

In most experiments 20 or 30 plants per treatment were used, and there were several replications of most of the experiments, some of the averages being based on over 100 cases. The statistical significance of the differences was determined by the calculation of "t" values.

RESULTS

In the first experiment MH inhibited growth significantly in coleoptiles less than 10 mm. long at treatment whether applied terminally or unilaterally, and there was no significant difference in the results of the two methods of treatment, but the MH did not inhibit the growth of coleoptiles which were more than 10 mm. long at treatment (Table I). The roots of both groups of seedlings were markedly inhibited by MH. No growth curvatures occurred in any of the coleoptiles treated unilaterally. There were no significant differences in growth inhibition by the various concentrations of MH. The degree of phototropic and geotropic response of the treated plants in the second experiment was as great as that of the controls, and although response time was not measured there was no obvious difference in it.

In the third experiment the mean growth of the control roots was 4.0 mm.,

that of the roots of seedlings treated with MH on the coleoptile stump was 0.5 mm. and that of the plants growing in agar containing MH was 0.2 mm., the differences between the two treated groups not being statistically significant.

In the fourth experiment, in contrast to the results in the first, the *Avena* coleoptile sections cut from the coleoptiles more than 10 mm. long as well as those cut from the coleoptiles less than 10 mm. long were significantly inhibited in growth by MH (Table II). No concentration of indole-3-acetic acid used in experiment 5 significantly affected growth inhibition by MH, nor did calcium

TABLE I

Effect of terminal and unilateral applications of MH in lanolin on the growth of intact Avena coleoptiles

COLEOPTILE LENGTH AT TREATMENT	GROWTH PERIOD	LOCUS OF TREATMENT	MH CONC., P.P.M.	MEAN GROWTH	
				mm.	% of controls
	hours				
Less than 10 mm.	62	Terminal	0	35.5	—
			500	28.3	79.7*
			1000	24.5	69.0*
			2000	28.5	80.3*
		Unilateral	0	35.2	—
			500	27.5	78.1*
			1000	24.1	68.5*
			2000	28.3	80.4*
More than 10 mm.	40	Terminal	0	21.0	—
			500	22.3	106.2
			1000	20.9	99.5
			2000	22.3	106.2
		Unilateral	0	21.0	—
			500	23.0	109.5
			1000	21.5	102.4
			2000	21.0	100.0

* Difference significant at 1% level or less. Other differences not significant.

nitrate or thiamin in experiment 6 affect MH growth inhibition (Table II). While all sections in thiamin grew more than the treated sections without thiamin the differences lacked significance even at the 5% level due to the rather marked variability in the growth of the treated sections. However, both ferric sulfate and boric acid significantly reduced the MH growth inhibition (Table II).

DISCUSSION

The failure of MH in lanolin to inhibit growth of coleoptiles more than 10 mm. long, the lack of growth curvatures resulting from unilateral applications of MH, and the lack of a MH effect on phototropic and geotropic responses all indicate that MH did not affect cell elongation. These results and the lack of effect of various concentrations of IAA on MH growth inhibition of *Avena* sections both suggest that MH was not acting as an anti-auxin under the conditions of these experiments. These experiments differ from those of Leopold and

Klein (1951, 1952) with slit peas in that they used lower concentrations of both MH and IAA, the maximum relief of growth inhibition by either 3 or 10 mg/l MH having been obtained by use of 10 mg/l IAA. The inhibition of growth

TABLE II

Effect of MH and MH combined with various concentrations of indole-3-acetic acid, selected mineral salts, and thiamin on the growth of Avena coleoptile sections during a 20 hour growth period

COLEOPTILE LENGTH AT TREATMENT	MODIFICATIONS OF THE BASIC CULTURE SOLUTION*	MEAN GROWTH		
		mm.	% of controls	% of MH alone
Less than 10 mm.	Controls (less MH)	13.7	—	—
	Basic solution	3.8	27.7†	—
More than 10 mm.	Controls (less MH)	8.2	—	—
	Basic solution	2.6	32.1†	—
More than 10 mm.	Controls (less MH)	9.3	—	—
	Basic solution	4.4	47.3†	—
	10 mg/l IAA	4.2	45.1†	95.5
	25 mg/l IAA	4.5	48.3†	102.3
	50 mg/l IAA	4.4	47.3†	100.0
	100 mg/l IAA	4.4	47.3†	100.0
More than 10 mm.	Controls (less MH)	4.2	—	—
	Basic solution	0.7	16.6†	—
	$Fe(SO_4)_3$ 5 mg/l	2.2	52.2†	301.4†
	10 mg/l	1.7	40.3†	232.9†
	$Ca(NO_3)_2$ 200 mg/l	0.7	16.6†	100.0
	400 mg/l	0.6	14.3†	85.7
	600 mg/l	0.7	16.6†	100.0
	800 mg/l	0.7	16.6†	100.0
	1000 mg/l	0.8	19.0†	109.6
	H_3BO_3 1.5 mg/l	1.0	23.8†	142.9†
	3.0 mg/l	1.1	26.2†	157.1†
	4.5 mg/l	0.9	21.4†	128.6†
	6.0 mg/l	1.0	23.8†	142.9†
	7.5 mg/l	1.2	28.5†	164.4†
	Thiamin 0.1 mg/l	1.0	23.7†	142.9
	0.2 mg/l	0.9	21.4†	128.6
	0.3 mg/l	0.8	19.0†	109.6
	0.4 mg/l	0.8	19.0†	109.6
	0.5 mg/l	0.8	19.0†	109.6

* Basic solution: 20 g/l sucrose, 3 mg/l IAA, 1 g/l MH.

† Significant at 1% level or less. Other differences not significant.

of the *Avena* sections from coleoptiles more than 10 mm. long in the fourth experiment of the present study indicates that MH did inhibit cell elongation in this case, and that it may have been acting as an anti-auxin. In general, the available data suggest that while MH in adequate quantities appears to inhibit cell division under almost any condition, it inhibits cell elongation only under

certain conditions. On the basis of the available results it appears possible that some such factor as low oxygen availability to the tissues might be a prerequisite to an effect of MH on cell elongation or as an anti-auxin. This point should be worth while investigating.

The comparatively small amount of growth of even the control sections in experiment 6 (Table II) was apparently due to the fact that these sections were taken from somewhat older coleoptiles than in the other experiments on *Avena* sections, and makes the data of less value than they might otherwise be. However, the marked effect of both Fe $(SO_4)_3$ and H_3BO_4 in overcoming partially MH growth inhibition strongly suggest that MH may in some way affect boron and iron or sulfur metabolism, at least in its effect on cell elongation. Further investigation of the effects of these and other ions on MH growth inhibition is planned.

SUMMARY

Maleic hydrazide in lanolin applied either terminally or unilaterally significantly inhibited the growth of intact *Avena* coleoptiles less than 10 mm. long at treatment, but not of those more than 10 mm. long. No growth curvatures occurred in any coleoptiles treated unilaterally, nor did MH affect geotropic or phototropic responses of *Avena* coleoptiles. MH significantly inhibited growth of the roots of *Avena* seedlings, whether added to agar in which the roots were growing or applied to coleoptile stumps. MH inhibited growth of *Avena* sections whether they were taken from coleoptiles more or less than 10 mm. long, indicating an effect on both cell division and cell elongation under these conditions, but an effect on cell division alone in the first experiment. Various concentrations of IAA from 3 to 100 mg/l had no effect on growth inhibition of *Avena* sections by 1 g/l MH. $Fe(SO_4)_3$ and H_3BO_3, but not $Ca(NO_3)_2$ or thiamin, partially overcame MH growth inhibition of *Avena* sections.

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THE OCCURRENCE OF THIN-WALLED SPORANGIA IN PHYSODERMA ZEAE-MAYDIS ON CORN IN THE FIELD[1]

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The thin-walled sporangia of several species of *Physoderma* have been reported by Schröter (1883), Büsgen (1887), and Clinton (1902)[2] on material collected in the field.

In the species *Physoderma zeae-maydis*, which is economically much the most important species of the genus, no report has yet appeared of thin-walled sporangia in the field. The present note is to record their discovery in the field.

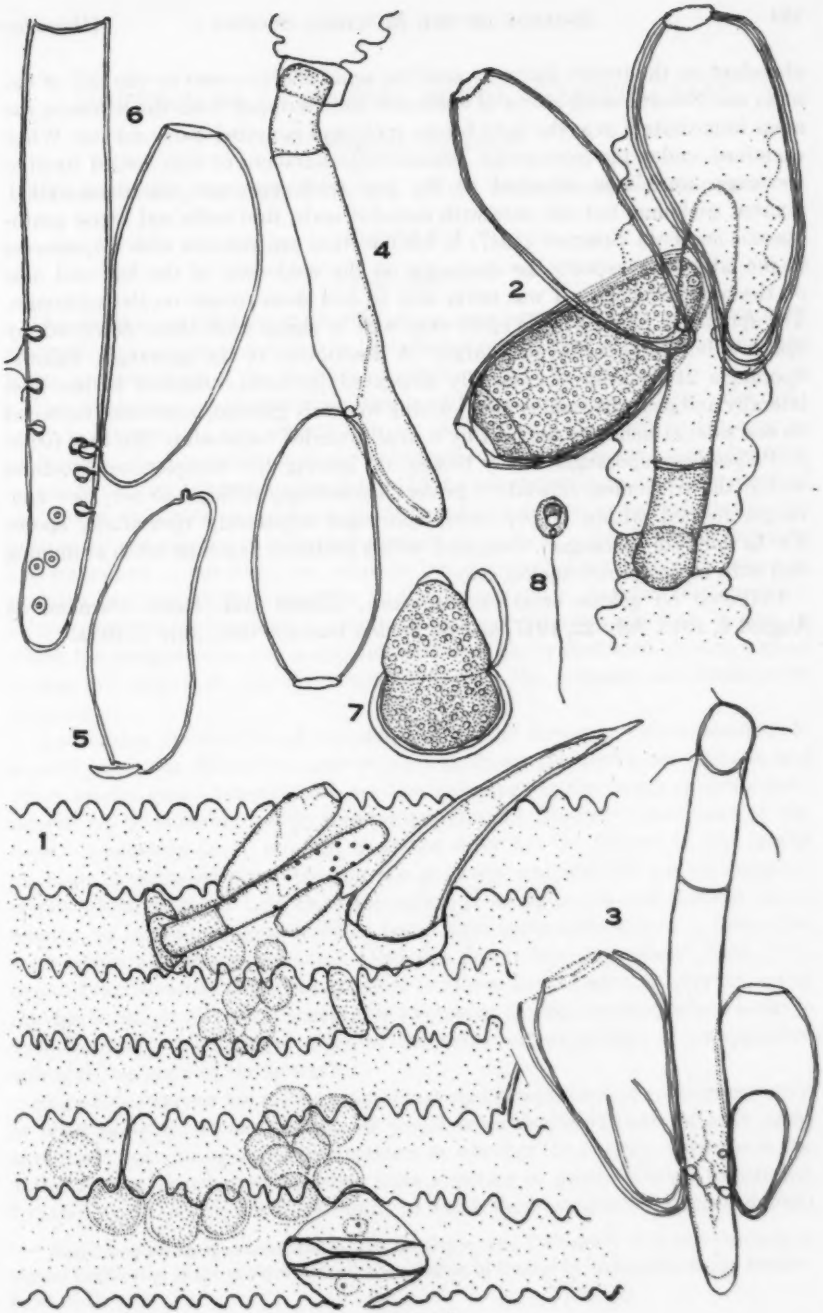
In 1934 Sparrow briefly described the formation under laboratory conditions of the thin-walled sporangia of *P. zeae-maydis*. Zoospores produced by resting spores were placed in a hanging drop with a piece of a very young leaf of golden bantam corn and after three days somewhat irregular, slipper-shaped sporangia were formed. These formed many zoospores similar to those from resting sporangia except markedly smaller. Sparrow also described the formation of new sporangia within the empty ones by internal proliferation. This work reported briefly by Sparrow (1934) was repeated and described by him much more fully in 1947. These experiments were repeated by Kelman and Hebert at Raleigh, North Carolina, obtaining much the same results as Sparrow. They did not observe thin-walled sporangia in the field (personal communication from Dr. Kelman).

While looking for resting sporangia for Dr. Sparrow on golden cross bantam corn in my garden in 1946, stages in the development of the brown resting bodies of *Physoderma* were found which were so young that all one could see were small, light brown specks hardly larger than a fly speck. These were particularly

[1] Presented at the Botany Section of the 50th Annual Meeting of the N. C. Academy of Science at Raleigh, May 8–9, 1953.

[2] For literature on *Physoderma* see Sparrow. Amer. Jour. Bot. **34**: 94–97. 1947.

Fig. 1. Semi-diagram of epidermis of corn leaf with some chlorenchyma tissue showing pointed and blunt trichomes and *Physoderma* infection. ×441 (high dry). Drawn May 4, 1953 from preserved slide. Material collected August 5, 1946 on golden cross bantam corn. Fig. 2. Three clusters of sporangia on one trichome. ×762. Collected August 6, 1946, golden cross bantam corn. Several seen with zoospores. Fig. 3. Two clusters of sporangia on one trichome. ×762. Collected and drawn July 7, 1952, on golden bantam corn. Corn almost maturing. Fig. 4. One sporangium on trichome. ×762. Collected August 6, 1946. Fig. 5. One empty sporangium floating in water. Note minute papilla where sporangium was attached, also operculum. ×762. Fig. 6. One sporangium on trichome and several infection scars. ×1200. Fig. 7. Resting body germinating in water. ×912. Collected July 27, drawn July 29, 5 p.m. Fig. 8. Resting body zoospore. ×1200.



FIGS. 1–8

abundant on the tender leaves around the small abortive ears on the side of the main ear. Several small pieces of epidermis were stripped from the leaves in the areas immediately over the light brown spots and mounted outer side up. When examined under the microscope, considerable numbers of thin-walled hyaline sporangia were seen attached to the leaf trichomes—not the thick-walled pointed trichomes but the ones with rounded ends, thin walls and dense protoplasmic contents. Sparrow (1947) in his infection experiments with *Physoderma* in the laboratory reports the sporangia on the epidermis of the leaf and also on the blunt trichomes. I was never able to find them except on the trichomes. The sporangia found by me agree very well in shape with those described by Sparrow but are considerably larger. A description of the sporangia follows: Sporangia 21–34 x 45–84μ; usually elongated pyriform, attached to the host laterally and near the smaller end, varying to nearly globose, sometimes flattened on one side; attached to the host by a small rounded haustorium like that found in *Phlyctidiun*; sporangia easily broken off leaving the conspicuous haustoria within the trichomes; rhizoids if present exceedingly difficult to see; new sporangia formed within empty ones; sporangia apparently operculate, spores 3.3–4μ thick (in sporangia), elongated with a posterior flagellum when swimming and with an indistinct nuclear cap.

Collected on golden cross bantam corn, Chapel Hill, North Carolina on August 6, 1946, July 22, 1947, and on golden bantam corn, July 7, 1952.

MORPHOLOGICAL STUDIES IN THE CELASTRACEAE*

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Plates 3–4

Introduction

The studies reported upon in this paper were undertaken in an attempt to ascertain the nature of the disc in the celastraceous flower, and its relationship to an interpretation of the superior or inferior nature of the ovary.

The writer was led to undertake this investigation when he encountered difficulty in interpreting the present day use of the term disc, while attempting to understand the composition of the celastraceous flower. Several examples may make the nature of the confusion clearer. Certain manuals in common use describe the flower with such expressions as "stamens inserted on a disk which fills the bottom of the calyx and sometimes covers the ovary"; "pistil free or more or less imbedded in the disk; i.e., more or less inferior." Other manuals take the position that the ovary is superior in the entire family. A series of supposedly related families is described in one text as being "characterized by flowers in which the receptacle or axis is expanded into a disk, or deepened to form a more or less urn-shaped or cup-like structure bearing the perianth and stamens on its margin".

One seeking to understand the structure of the flower in Celastraceae finds several questions difficult to answer after studying the above descriptions and other similar ones. Among these are the following: Is the ovary properly considered to be superior, partly-inferior or inferior? Precisely what part of the flower is properly to be referred to as the disc? Do the flowers of this family have an invaginated axis "bearing the perianth and stamens on its margin", or one which "fills the bottom of the calyx", bearing petals and stamens on its margin, or is the disc considered to be an axial outgrowth arising between the androecium and the gynoecium? Does the flower have a perianth tube, or a perianth-androecium tube? What is the evidence for the axial interpretation of the disc in this family? Is it acceptable to present day anatomists, or is it a carry-over from an earlier period prior to the many recent studies of comparative vascular anatomy of the flower?

Since Celastraceae are rather generally accorded a position of some importance in most systems of classification, it would seem desirable that we have some agreement concerning such basic matters as whether the ovary is superior in the entire family, or whether it varies from superior to partly-inferior to inferior. In other words, is or is not this a family in which there is a gradual transition from

* Based upon a thesis submitted to the faculty of the University of North Carolina in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Botany.

the hypogynous to the epigynous condition? If such a transition is evident here, what is the nature of the tissue in which the ovary is gradually becoming imbedded?

That the axial interpretation of the disc is based upon well established evidence is not apparent. The concept of the invaginated axis, or of an upgrowth of the axis, as an explanation of the origin of the inferior ovary, which has been so strongly held at various periods of botanical history, has recently been under vigorous attack by those who stress the value of evidence derived from studies of comparative floral vascular anatomy. It seems possible that an axial interpretation of the nature of the disc may date from a period when a similar interpretation of all inferior ovaries was widely accepted. Douglas (1944), who has reviewed the very extensive literature on the subject of the inferior ovary, concluded her review with the following statement: "Recently we have witnessed a reëmphasis on the method of comparative vascular anatomy which has furnished criteria for determining when the outer wall of an inferior ovary consists of a truly invaginated axis, and when it represents an adnation of floral appendages. In the former case, the stelar bundles, running to the top of the ovary, after giving off traces to the three outer whorls, bend backward, and in the course of their downward descent give off the carpel traces. In the latter case there exist all degrees of fusion between bundles of adnate floral whorls before the tangential splitting takes place which frees them from each other, but there is no invagination. Thus two types of inferior or semi-inferior ovaries can be demonstrated. Contrary to popular opinion, however, the type which is characterized by a truly invaginated axis is rare. Thus far we know it only in *Rosa*, *Calycanthus*, the family Santalaceae and possibly in the Juglandaceae. In the majority of other flowers the inferior ovary appears to be a structure composed of the fused basal portions of the calyx, corolla, stamens adnate to the fused carpels."

Eames and MacDaniels (1947) summarize the situation as follows: "It is apparent that an inferior ovary can be formed by the adnation of the sepals, petals and stamens to the carpels or by the sinking of the gynoecium in a hollowed receptacle, with fusion of the receptacle walls about the carpels. From anatomical evidence, it is clear that the inferior ovary in nearly all families is made up of appendages fused to the carpels".

In seeking answers to questions such as those posed above, it would be well to have clear definitions of terms and acceptable criteria for evaluating any evidence which might be brought forth in a study of the flower. In seeking definitions of terms such as *superior ovary* and *inferior ovary*, we immediately run into difficulty. As in the case of definitions of the disc, we find such words defined in terms of only one interpretation of the character of the tissues which may surround the ovary. Thus an inferior ovary is defined as "one that is adnate to the calyx", or a superior ovary as being one which is "wholly free from the receptacle."

All of the above may seem to some to be mere academic hair-splitting, but since some of these definitions are clearly contradictory and highly misleading, it would seem to be important for a writer to use them with caution, and attempt

to make clear his own definition of the terms. Reference to the accompanying figures of *Euonymus* (Figs. 11–12) for example, will make clear the difficulty one encounters in attempting to describe the flower in terms of many of these definitions. The difficulty seems to arise from the fact that the taxonomists, in dealing with flowers which are not clearly hypogynous, have tended to interpret all of them either in axial or appendicular terms, and have framed their definitions accordingly. Seldom do their definitions seem to take into account the long continued debate between axial and appendicular schools of thought, or the probability that flowers may exist of each of these origins. Smith and Smith (1943) in the preface to their monograph on the Santalaceae, one of the few families apparently accepted by both schools of thought as having a receptacular inferior ovary, stress this point. "The authors recently described the floral anatomy of *Darbya*, in which the inferior ovary is interpreted as receptacular. It was specifically stated, however, that this interpretation applies only to the Santalaceae. Acceptance of the receptacular theory for this family does not deny the existence of the appendicular inferior ovary in other families. In fact, the evidence used to support the receptacular nature of the inferior ovary in the Santalaceae may also be considered as confirming the appendicular nature of the inferior ovary in other forms. This is so because the anatomy of the receptacular inferior ovary is characteristic and entirely distinct from that of the appendicular type. The floral anatomy of the inferior ovary as it occurs in the higher monocots and in most of the higher dicots, can be adequately interpreted only in terms of cohesion and adnation, while the anatomy of the inferior ovary in the Santalaceae seems impossible of explanation except in terms of invagination of the floral axis. There has been a tendency on the part of some botanists to assume that these two theories are mutually exclusive, and that to accept one is to reject the other. The inferior ovary has undoubtedly appeared independently in different plant lines and there is no reason why all should have the same structure. For example, in the Olacaceae, a few species of which are described in this paper, it seems likely that two and perhaps all of the three possible types of inferior ovary occur in this one family."

The writer agrees with Smith and Smith that many botanists have "assumed that the two theories are mutually exclusive", and have formed their definitions accordingly. He cannot agree, however, that "the anatomy of the receptacular inferior ovary is characteristic and entirely distinct from the appendicular type". The evidence from Santalaceae, *Rosa*, *Calycanthus*, and from these studies of Celastraceae, indicate that they are open to an interpretation other than the receptacular one which has been given them.

Unless clearly specified otherwise, the writer is using the following terms in the remainder of this paper as defined below. No doubt the definitions have defects, and can be improved upon, but it is felt that they have the virtues of recognizing the existence of differences of opinion, and of being rather explicit.

Disc—a tissue of various form, often glandular, appearing to be intrusive among the whorls of floral parts and often more or less adnate to one or more of them, variously interpreted as being axial or appendicular in origin.

Superior ovary—An ovary whose outer wall is not adnate to any other tissues above the level of the base of the locules.

Semi-inferior ovary—an ovary whose outer wall is adnate to other tissues above the level of the base of the locules, but not to the level of the top of the locules.

Inferior ovary—an ovary whose outer wall is adnate to other tissues from its base to the level of the top of the locules or above.

Hypogynous flower—one with a superior ovary, which does not stand in a cup of other tissue.

Semi-epigynous flower—one with a semi-inferior ovary.

Perigynous flower—one whose superior ovary stands in, but free from, a cup of other tissues.

Epigynous flower—one with an inferior ovary.

On the assumption that evidence from vascular anatomy is at least as valid as any we have for the interpretation of matters of floral morphology, this investigation has sought to determine whether or not the present day vascular picture can shed any light on the origin of the tissues present in the flowers of this family.

MATERIALS AND METHODS

The family Celastraceae is divided by Lösener (1896) into four subfamilies as follows: I. Celastroideae II. Tripterygioideae III. Cassinioideae and IV. Goupioideae. The basis of this division is primarily the type of fruit produced. Of these subfamilies, only the Celastroideae contains genera readily available in this area for the frequent collections of material essential for the ontogenetic studies which are necessary in the interpretation of the vascular anatomy of the fully developed flower. This subfamily was therefore selected for this investigation.

The subfamily Celastroideae is further divided into two tribes, the Euonymeae and Eucelastreae, and includes seventeen of the thirty-five genera recognized by Lösener. Of these seventeen genera, *Euonymus*, *Celastrus* and *Pachistima* were available. The species studied were *Euonymus americanus* L., *E. atropurpureus* Jacq., *E. japonica* L., *E. alata* Reg., *Celastrus scandens* L., *C. orbiculatus* Thunb., and *Pachistima canbyi* A. Gray.

Collections of buds, flowers and fruit were made at frequent intervals throughout the year. These were preserved in F.P.A. fixative (commercial formalin 5 parts, propionic acid 5 parts, and 50% ethyl alcohol 90 parts) and were stored in the fixative until needed for study. At this time they were dehydrated by the tertiary butyl alcohol method and embedded in paraffin.

Serial sections were cut at 10 microns, stained for 15–20 hours with safranin in 50% ethyl alcohol, counter stained with aniline blue in clove oil, cleared in Euparal essence and mounted in Euparal. Both cross and longitudinal sections were prepared and studied. All drawings were made with the aid of a camera lucida. For the larger sections, or for complete flowers, a dissecting microscope was used. Details of the sections were completed free hand as studied with the higher powers of the compound microscope.

Flowers which were stored for a time in a 1:1 mixture of paraffin oil and tertiary butyl alcohol were cleared, making it possible to study many features of the vascular anatomy in the complete flower with a dissecting microscope.

FLORAL MORPHOLOGY AND ANATOMY

A. *Celastrus*

Celastrus is considered, for a number of reasons which will be discussed later, to be the most primitive genus of the three studied. It is described first with a view to making the descriptions of the other two genera easier to understand. The attempt will be made to show that the type of flower found in *Euonymus* and *Pachistima* could have been derived without difficulty from a type comparable to that of *Celastrus*, or that the two types could easily have arisen from a common ancestor.

Two species of *Celastrus* were studied, namely, *C. scandens* L. and *C. orbiculatus* Thunb. The two species differ primarily in leaf shape, and in the axillary or terminal position of the flower clusters. Since no significant differences in floral morphology were noted, the description which follows applies equally well to both species.

The flowers of *Celastrus* are polygamo-dioecious, some flowers having well developed stamens and a reduced pistil, others having both stamens and pistil well developed. The tri-locular ovary is superior and stands in, but free from, a cup of other tissue. The flower is thus perigynous as here defined. The typical flower has five sepals, five petals and five stamens, but flowers were observed which had six petals, six stamens and five sepals, of which one was quite large and four were of normal average size. The sepals, petals, and stamens (or the free portions of these), become free from the cup at a level opposite the top of the locules of the ovary (Figs. 1–3). Thus the ovary is surrounded by, but free from, a cup of tissue, to the rim of which are attached the free floral parts. Stamen filaments depart from the top of the rim of this cup, opposite the sepals. Between filaments, opposite petals, there are small projections of tissue, extending upward a short distance above the point at which the filaments become free (Figs. 1–3). The entire cup is interpreted here as consisting of fused bases of floral parts and can be properly referred to as the floral tube, as suggested by Jackson (1934) for *Rosa*. The inner layer of the floral tube is considered to be composed of fused basal portions of presently existing stamens and of stamens no longer present. This tissue, i.e. that of reduced stamens between the presently existing ones, constitutes the disc. It is glandular in nature, as are the stamen bases, nectar being secreted apparently from the entire base of the androecium into the bottom of the tube around the base of the ovary.

The basis for the above interpretation of the nature of the tube is found in the behavior of the vascular supply to the flower. Sections through the upper portion of the pedicel show eight large traces departing from the stele at approximately the same level. These soon become ten through the radial division of two of them (Fig. 10). Five of the ten ultimately provide vascular supply to the sepals and stamens, and vestigial strands to the tissue between the stamens. These five

traces pass outward and upward to approximately the level of the base of the locules, at which point they separate tangentially into two distinct traces (Fig. 1). Very soon after their separation the innermost, or stamen, traces each give rise to two fine vascular strands which depart from the inner face of the traces, pass inward slightly and bend back to a position on either side of the stamen trace and extend upward parallel with it for a short distance and disappear (Figs. 8–9). The outermost trace formed by the tangential separation continues unbranched into the free part of the sepal where it divides radially to form median and lateral sepal bundles.

The remaining five traces of the original ten alternate with the first five. They depart from the stele at the same general level, pass outward and upward without branching until they reach a level about opposite the middle of the locules of the ovary. At this point they make a very limited tangential division into two traces (Figs. 1–2). The outer one of these continues unbranched into a petal. The inner trace breaks up into a number (4–6) of small strands almost as soon as it forms, and is entirely used up in the formation of the strands. These separate radially and pass upward inside of the petal trace into the disc in the plane of the staminal whorl (Figs. 1, 2, 6, and 7). They extend in the disc above the level at which the petals become free.

At the point of the departure of the ten (8) large traces from the stele there are also a number of smaller traces. Three of these bend outward slightly and then upward, as the three dorsal traces to the carpels. Six others move out and upward into the septa, as the median carpel traces, and the remaining six move inward and upward as the ventral carpel traces. The stele appears to be completely used up in the formation of these traces (Figures 1, 3 and 10).

The six ventral carpel traces send branches into the placenta supplying the pairs of anatropous ovules in each locule. Ventral traces of adjacent carpels then move together and unite, forming three large bundles which continue upward, with occasional branching, to the base of the style where they again separate into six distinct bundles. The dorsal and median carpel traces also branch to some extent in the ovary wall and continue into the style. Thus the style shows a large number of small bundles in cross section (Figs. 1, 3–5).

The vascular anatomy of the flower described above indicates that the stele should be considered to end at the point where the traces of the floral tube diverge from the upwardly directed carpel traces. All of the traces departing from this point are clearly floral, not stelar, in nature. This may seem to be obvious in *Celastrus*, but becomes less so in *Euonymus* and *Pachistima*. The vascular strands which separate tangentially from stamen and from petal traces and extend into the disc in the position of the staminal whorl seem best interpreted as representing vestiges of the vascular supply of stamens which have become reduced to the extent of the disc tissue now present between the existing stamens. The disc is considered to be a part of the floral tube.

B. *Euonymus*

Four species of *Euonymus* have been included in this study, namely, *E. americanus* L., *E. atropurpureus* Jacq., *E. alata* Reg., and *E. japonica* L. The first of

these, *E. americanus*, has a pentamerous flower. The other three have tetramerous flowers. *E. americanus* will be described first.

1. *Euonymus americanus* L. The typical flower of *Euonymus americanus* is pentamerous but occasionally a tetramerous one is seen. At first glance the flower would seem to differ decidedly from that of *Celastrus*, but careful study reveals that they have much in common. The ovary is not free from the surrounding tissues as in *Celastrus*, but is adnate to them up almost to the level of the top of the locules, only the top of the ovary being free (Figs. 15–16). The ovary is thus considered to be semi-inferior, and the flower to be semi-epigynous. The tissues which surround the ovary form a broad, flat structure usually referred to as the "disc". The filaments of the stamens are extremely short and stubby and are attached to the edge of the disc. The petals alternate with the stamens and attach underneath the edge of the disc as do the sepals opposite the stamens. The exposed surface of the ovary is covered with papillae which first appear several weeks before anthesis. These do not extend to the style and are not found along the midribs of the carpels (Figs. 11–13). The papillae become the conspicuous spines of the fruit (Figs. 13, 28). An interesting feature of the papillae is that each of them bears a stoma, with large guard cells, at its apex (Fig. 14).

When the flower is fully open, the surface of the so-called disc has certain areas sharply outlined by differences in pigmentation and by the great abundance of nectar which covers a well defined region of the disc (Figs. 11–13). This nectar attracts a great variety of insects. The nectariferous area is usually more or less rose colored, and is thus set off from the green papillate surface of the ovary and from regions around the base of each filament (here referred to as staminal cushions) which are a greenish-white in color (Fig. 12).

The broad flat structure surrounding the ovary, to the edge of which are *apparently* attached the stamens, petals and sepals, is here interpreted as being a floral tube, comparable to that of *Celastrus*, composed of fused basal portions of sepals, petals, stamens and basal tissue of stamens no longer present as such. The latter, which were considered to be the disc in *Celastrus* are so considered here. Such a structure could readily be derived from the *Celastrus*-type of flower by adnation of the lower part of the floral tube to the ovary and a turning outward of the top of the tube. This turning outward would bring the inner surface of the upper part of the tube to the position of the flat surface in the *Euonymus* type, and free parts of stamens, petals and sepals from the rim of the tube to the outer edge of the flat surface. This transition is suggested to some extent by the buds of *Euonymus*, before the outward turning of the upper portion of the tube has occurred, and the various floral parts have the same morphological relationship as in *Celastrus* (Figs. 21–24). The outward turning of the upper portion of the tube seems correlated with the expansion of the ovary. As the ovary continues to enlarge the flat portion of the floral tube turns downward (Figs. 13, 25–28). This process is continued, and in the mature fruit, stamens, disc and sepals are directed downward around the pedicel (Fig. 28).

The development by the floral tube of a flat surface around the top of the ovary should probably be considered to be more a matter of phylogeny than ontogeny, since even in the buds the floral tube is less cup-like than in *Celastrus*. The vascu-

lar anatomy of *E. japonica*, which will be described, also indicates that the *Celastrus*-type of floral tube was not necessarily a stage in the evolution of the *Euonymus* type, but that both might readily have been derived from a common ancestor.

Further evidence of the soundness of the interpretation of the floral tube is obtained from the vascular anatomy.

Cross sections through the pedicel show ten large traces departing from the stele (Figs. 18–19). These pass outward and upward around the ovary. Five of them divide tangentially immediately below the base of the locules, each forming two strong traces (Fig. 15). The inner trace moves inward and upward around the ovary and is the dorsal carpel trace. The outer trace passes upward and outward to a point opposite the center of the locules of the ovary. Here it gives off by tangential division two strong branches on either side from its outer or lower surface (i.e. the two traces, while separating tangentially from the main petal trace, diverge radially on either side of it). These, which are considered to be lateral sepal traces, branch several times within the flattened floral tube and extend beyond it into the free part of the sepal (Fig. 16). The remainder of the main trace passes into the free part of the petal (Fig. 15). The other five, of the original ten, traces move outward and upward to a point opposite, and slightly below, the center of the locules, where they divide tangentially (Fig. 16). The outermost trace of the two formed by this division continues to move upward and outward, ultimately forming the central supply to the free part of the sepal. The inner trace continues vertically to a point opposite and above the center of the locules, where it makes a right angle bend outward and moves horizontally for some distance before curving upward into a filament of a stamen (Fig. 16).

Sections through the pedicel before the departure of any floral traces show a dissected stele roughly circular in outline (Fig. 20). At a slightly higher level, the broad stubby origins of the ten large traces become evident (Fig. 19). At still higher levels the stele with its ten traces assumes a star shaped outline, five of the traces departing from the points and five from the angles (Fig. 18). The latter five separate first from the stele, and are sepal-stamen traces. The five traces at the points of the star are the fused dorsal carpel, petal and lateral sepal traces. As the sepal-stamen traces separate from the stele, five strong bundles can be seen in cross section, one in each angle of the star. These are ventral carpel traces, and contain lignified xylem. There are traces on either side of the ventral carpel traces which lack lignified xylem. Thus we have five groups of three traces each continuing upward into the placental region (Fig. 17). The ten traces which show no lignified tissue finally supply the ten anatropous ovules. The five ventral carpel traces continue into the style where each divides to form two. Thus ten continue to the stigma. Dorsal carpel traces branch freely, especially at the top of the ovary. Ventral traces branch occasionally but not freely.

The evidence of adnation of floral parts while strong in *Celastrus*, is even more extensive in *Euonymus americanus*. Dorsal carpel traces, which were free in *Celastrus*, are here adnate for a part of their extent to the petal traces. Sepal laterals are adnate to the petal traces almost to the edge of the floral tube. Stamen

and sepal traces which separate below the locules in *Celastrus*, are here united to a level midway of the locules. While no evidence of vestigial strands of vascular tissue supplying the disc tissue between the stamens could be found, this should not be surprising in a flower showing evidence of considerably more adnation. The *Euonymus* flower is therefore considered to have been derived from a type comparable to that of *Celastrus* or from an ancestor common to both, through increased foreshortening of the axis, resulting in increased adnation of all floral parts including the gynoecium.

Since the ventral carpel traces, and the placental traces move upward and inward from essentially the same point at which all of the other traces depart from the stele, this point must constitute the limit of the extent of the stele. The angle formed by these traces is only what might be expected when laterally placed carpels assume a vertical position in uniting to form a pistil.

2. *Euonymus atropurpureus* Jacq. The flower of this species differs from that of *Euonymus americanus* primarily in that it is tetramerous and that the ovary is imbedded in other tissues only at its base. The ovary is semi-inferior and the flower is *semi-epigynous*. The derivation and composition of the floral tube are considered to be the same as in *Euonymus americanus*.

Sections through the pedicel of the flower show a dissected stele of numerous bundles. From this stele seven large traces move out almost horizontally. One of these is as wide as any two of the other six. That it consists of two, comparable to the other six, which have become fused, is made evident by the fact that it separates radially after moving out horizontally for some distance from the stele, to form two large traces (Fig. 30). Four of the traces, including one half of the extra large trace, are the sepal-stamen traces and each divides tangentially. The upper trace resulting from each division turns upward into a stamen filament. The lower trace turns downward into the free part of a sepal, as the median sepal bundle (Fig. 29). Each of the latter gives off a branch at right angles just before entering the free part of the sepal. This branch extends for some distance at right angles to the median bundles and then turns outward into the free sepal.

The remaining four traces of the original eight (including one half of the extra large trace) are the petal-carpel-lateral sepal traces. These give rise from their upper surface to median carpel traces below the center of the locules and to dorsal carpel traces beyond the outside of the locules. After giving off the dorsal carpel traces, the main trace divides again, giving off lateral sepal traces from the lower surface, before entering a free petal. (Fig. 32).

The dorsal carpel traces are of especial interest, in that they do not simply swing gradually upward away from the main trace, as in *E. americanus*, but first bend back inward before swinging out and upward around the ovary (Fig. 32). Their appearance suggests that adnation of carpel and petal has carried them beyond their normal turning point.

The ventral carpel traces become visible in cross section as the seven large traces depart from the stele (Fig. 30). They swing outward slightly and then turn sharply back toward the center as they move upward. They send out very numerous strong branches into the septa at various levels, and branches into the pairs

of anatropous ovules in each locule. After giving off branches to the ovules, the two ventral traces in each septum fuse to form a single strong trace. These traces contain much lignified xylem tissue, in contrast to the dorsal and median traces which become weak and contain relatively little lignified tissue above where they turn upward in the outer ovary wall. The ventral traces continue to send branches into the septa at all levels of the ovary. At the base of the style they separate again into eight traces and continue thus throughout the style (Figs. 29–32).

As was observed in *Euonymus americanus*, there are strong indications of adnation of floral parts in this flower. Stamen traces are adnate to sepal traces, carpel traces to petal traces, and one sepal-stamen trace is adnate to an adjacent carpel-petal trace. Median sepal traces form a single branch within the floral tube which extends into the free part of the sepal. Of especial significance is the fact that the dorsal carpellary traces are carried slightly beyond their turning up point by adnation to the petal trace, and must turn backward on themselves slightly before turning upward. The stele is considered to end at the point of origin of the original seven main traces.

3. *Euonymus alata* Reg. The flower of *Euonymus alata* gives a very much flattened appearance. The style is extremely short, and the ovary has considerably more width than depth. The ovary is imbedded in other tissues almost to the top of the locules, and is, therefore semi-inferior and the flower is semi-epigynous. The tissues by which the ovary is surrounded are interpreted as constituting the floral tube. The upper portion of the tube is turned outward and is octagonal in outline. The petals extend from four sides of the octagon, and short sepals from the other four sides. Short stamens rise vertically from the flattened tube opposite the sepals (Fig. 33).

The dissected stele of the pedicel gives rise to eight large traces which pass out horizontally (Fig. 34). Four of these consist of fused stamen and median sepal traces, and four of fused carpel, petal and lateral sepal traces. The stamen-sepal traces divide tangentially just outside the outer margin of the locules (Fig. 33). From this separation the upper, or stamen trace passes upward and outward to the base of the free filament of the stamen which it enters. The other half of the trace, the median sepal trace, passes outward horizontally and gives off one or more branches by radial division within the tube before entering the free part of the sepal. These branches are strong ones, and extend out into the free part of the sepal also.

The four carpel-petal-sepal traces give off from their lower surface by tangential division two strong sepal lateral traces which pass out radially in the fused tissue of sepals on either side of the petal. These lateral traces may or may not extend into part of the free tissues of the sepal (Fig. 34). The central portion of the trace remaining, after the separation of the sepal laterals, extends into the free portion of the petal. The dorsal carpel traces arise tangentially from the upper surface of these four traces. As in *E. atropurpureus*, the dorsal carpel trace is carried slightly beyond its point of turning upward by adnation to the petal trace beneath it. It, therefore, bends backward slightly on itself before turning up around the outer ovary wall (Fig. 35). From a point below the center of the

locules median carpel traces arise in pairs from the upper level of the carpel-petal-sepal trace. They pass upward and outward through the septa. The ventral carpel traces move outward a short distance as the main traces leave the stele, then inward and upward at a forty-five degree angle into the placental region (Fig. 35). Branches are given off to the pairs of anatropous ovules, and the pairs of weak ventral traces continue inward, without uniting, into the short style. The ends of the septa do not make contact with each other in the center above the point at which the ovules receive their vascular supply. Thus the conspicuous hollow of the center of the style is continued downward well into the ovary. Both median and dorsal carpellary traces are relatively weak traces, and do not extend to the top of the ovary.

The adnation evident here is comparable to that observed in *E. atropurpureus*, but seems to be a little more extensive. Lateral sepal traces, adnate to petal traces above them for part of their length, separate and largely complete their extent within the floral tube. The median sepal trace branches within the fused tissue of the tube. Carpel traces are carried outward slightly further by adnation to the petal traces than is the case in *E. atropurpureus*. Thus the ventral carpel traces originate slightly further out, and move inward at a sharper angle, and median traces move more upward as they pass outward through the septa. The stele is considered to be terminated at the point of origin of the eight common fused traces. The disc is interpreted as in *E. americanus*.

The fruit of this species is of considerable interest. The author has not seen it in the fully mature condition, as this shrub was not available when early collections were made. Rehder (1927) describes it as follows: "Fruit of normally four, but often one–three ovoid purplish pods 6–8 mm. long". The fruit of the shrub from which these collections were made rarely consisted of four pods, but much more common were one, two or three pods. It seems probable that pollination was incomplete, and that failure of ovules to continue development resulted in failure of expansion of the carpel containing them.

4. *Euonymus japonica* L. The flower of *Euonymus japonica* is tetramerous and semi-epigynous, having a semi-inferior ovary which is imbedded in other tissues only at its base. These tissues are considered to constitute a floral tube as in other species of *Euonymus*. Adnation of floral parts is evident here, but is much less advanced than in the other species studied. The order in which adnation of parts has occurred in this flower indicates that it never went through a stage comparable to *Celastrus*. That both were derived from a common, but more primitive, type as a result of adnation of floral whorls occurring in a different order seems evident. That the type of flower found in other species of *Euonymus* and *Pachistima* could have been derived from either type is not difficult to see.

Adnation of floral whorls in this species involves much less fusion of vascular supply than in any other species studied, but there is some such fusion. Sepal traces depart from the dissected stele at a lower level than other traces, and are free from the traces to other whorls. A distinct layer of non-vascular tissue separates the sepal traces from the stamen traces above them. The sepal traces do, however, show evidence of adnation between median and lateral traces, and

it is clear that only a small portion of the sepal remains free. The four sepal traces are very wide at their point of departure from the stele, and do not all behave in quite the same way. Some of them separate radially into three distinct traces, a median and two laterals, just as they turn upward and outward from the stele. Others do not make this separation until they have passed out further from the stele. All of them do divide, however, before reaching the free part of the sepal, and all three parts usually branch before entering the free part of the sepal (Fig. 39). After the sepal gaps in the stele close, eight more traces depart from the stele at essentially a common level (Fig. 39). Four of these are stamen traces which proceed upward and outward around the ovary to the base of the filaments. The other four traces are larger, and consist of dorsal and median carpel traces fused to a wide petal trace. These pass upward and outward beneath the locules, separating tangentially before reaching the edge of the floral tube (Fig. 38). The petal trace continues into the free part of the petal, and the median carpel traces begin to separate radially from the dorsal carpel trace just as they turn upward and inward away from the petal trace (Fig. 37). From the point of origin of the carpel-petal traces a large number of ventral carpel traces pass upward and inward into the placental region of the ovary where they continue almost to the top of the ovary before becoming consolidated into twelve distinct bundles. Eight of these twelve are completely utilized in supplying the four pairs of pendulous anatropous ovules (Fig. 36). The remaining four continue into the style where they branch or separate to some extent.

The disc in the fully opened flower of this species is a very dark green, as are also the stamen bases, in contrast to the very pale green color of the ovary, the outer limits of which can readily be seen. The disc tissue, between the present stamens, is considered to be most probably vestiges of tissue of suppressed stamens, but no vascular evidence could be found to support this view.

Adnation in this species seems to have proceeded basipetally, since it involves fusion of carpel and petal traces, and gynoceium and androecium are adnate, while adnation of sepal tissues to the tissues above them does not yet involve the sepal traces. That the stele must end at the point from which the stamen and carpel-petal traces depart, seems clear from the position of the ventral carpel traces.

Very little nectar is produced by the disc in this species. Small beads of it can be seen at the point where the filaments become free, but large quantities are produced from epidemal cells on the upper surface of the free portions of the petals. Large numbers of insects of many kinds, ants, beetles and flies swarm over the flowers.

C. *Pachistima canbyi* A. Gray

The flower of *Pachistima canbyi* is semi-epigynous with a semi-inferior ovary which is adnate to the floral tube almost to the level of the tops of the locules. The flower has four sepals, four petals, four stamens, and a bilocular ovary which retains some indications of a four carpellary origin. The style is short, but the ovary has considerable depth. The anatropous ovules extend vertically from the

base as in *Celastrus*, rather than horizontally as in *Euonymus*. As in *Euonymus*, the buds, before free floral parts have turned outward, show the same morphological relationship between parts as in *Celastrus*, except for adnation of the gynoecium to the floral tube. Studies of the vascular anatomy support the interpretation that this type of flower could have been derived from the *Celastrus* type or from a common ancestor.

The dissected stele gives rise to eight large traces which depart from the stele at a common level (Fig. 42). These are compound traces, formed by the adnation of various floral traces. Their composition is as follows: four of them consist of petal, dorsal carpel, and ventral carpel traces, and four of fused sepal, stamen and median carpel traces. Median traces of carpels on either side of a stamen have adhered to the stamen trace, which in turn is adnate to the sepal trace. These eight large traces bend outward and upward around the ovary. As they depart from the stele, the carpel-petal traces give off the ventral carpel traces (Fig. 44).

The eight original traces undergo no further division until they have passed upward around the ovary to a point midway of its vertical extent. At this level, median carpel traces separate from the stamen-sepal trace and move inward following the ovary wall to the top of the ovary. At a slightly higher level, the sepal trace separates from the stamen trace and passes out into the free part of the sepal. The stamen trace continues upward and out into a filament (Fig. 41). There seem to be no sepal lateral traces in *Pachistima*. At the same level at which median carpel traces separate from the stamen-sepal traces, dorsal carpel traces separate from petal traces. The dorsal carpel traces continue upward around the ovary wall to the top of the ovary, and the petal traces swing outward into the free portion of the petals (Fig. 44).

The ventral carpel traces move inward and upward into the placental region, supplying the four ovules, and continuing upward through the ovary into the style. The four pairs of ventral traces fuse to form four traces, two in each septum, arranged in a linear position (Fig. 42). The two innermost of the four each supply two ovules, but continue above the ovules as do the outermost two. The two outermost traces disappear before reaching the top of the ovary, but the inner two remain strong after supplying the ovules, and later separate to form four, two in each septum, and continue as four into the style.

The vascular adnation evident in *Pachistima* can only be explained in terms of fused floral whorls. The position of the ventral carpel traces and the adnation of the median carpel traces to the stamen-sepal traces, requires that the stele be considered to end at the point of origin of the eight main traces. The disc in this flower is interpreted as representing the bases of suppressed stamens. *Pachistima*, like all forms of *Euonymus* studied, shows a much higher degree of adnation of floral parts than does *Celastrus*, and it is not surprising to find no evidence of independent vascular supply to this tissue.

DISCUSSION

The axial or receptacular nature of the disc can certainly not be regarded as being established, whether the term be applied to the floral tube, or to tissues

intrusive between floral whorls, as the following quotation from Heinig (1951) indicates: "The disc in the Thymelaeoideae is in the form of a cup-like structure between the androecium and gynoecium or is fused to the base of the floral tube for almost its entire length." She gives the following interpretation of the structure: "On the basis of anatomical and morphological data it appears probable that the disc is a part of the androecium. That it represents a third whorl of vestigial stamens is not clear, however. The fact that the vascular strands are derived from each bundle of the floral tube or all of the stamen traces suggests that the strands may be the supply of extra stamens in either one or both whorls; possibly they may be branches in fascicles of stamens such as Wilson (1937), reports occurring in certain Parietales and Malvales; or they may even be the supply of stipular appendages homologous with the petaloid scales."

Heinig would seem to be on firm ground in interpreting a disc which receives vascular strands from floral bundles as being of appendicular rather than axial origin. Yet Smith and Smith (1943) have done just the reverse in their interpretation of a similar situation in *Anacolosa luzoniensis* Merr., and in the same family (Olacaceae) have interpreted a disc in *Aptandra Spruceana* Merr. as representing reduced stamens.

Thus we find anatomical studies resulting in both axial and appendicular interpretations of the origin of the disc, not only in different families, by different writers, but even by the same writers in a single family. It seems quite reasonable to suppose that the disc is not a floral organ *sui generis*, but rather a *quasi* organ or structure incidental to floral development in some forms.

It was shown earlier in this paper that Smith and Smith hold that the inferior ovary could have arisen by both axial (receptacular) and appendicular means, and that the two are not mutually exclusive. The writer agrees with this point of view, despite the fact that he is far from convinced that the receptacular interpretation is the only possible one for Santalaceae, *Rosa*, or *Calycanthus*, notable exceptions to the appendicular rule, according to Douglas (1944).

In order to make clear the reasons for questioning the receptacular interpretation of the inferior ovary in Santalaceae, *Rosa*, and *Calycanthus*, certain developments brought out in this study of celastraceous flowers should be reviewed.

It was shown that in *Celastrus* the ovary is superior, standing in a cup formed by a floral tube of fused stamen, petal and sepal bases. Partial fusion of traces, together with the presence of strands passing into the disc from petal and stamen bases, and the position of carpel traces, all support the view that the stele ends at the point of origin of all these traces below the ovary.

In *Euonymus japonica*, which has a semi-inferior ovary, it was seen that adnation of floral parts may proceed basipetally, involving adnation of the gynoecium and androecium before adnation of sepal and stamen traces. The termination of the stele at the point of departure of carpel-petal and stamen traces was indicated by the position of the ventral carpel traces.

The flower of other species of *Euonymus* and of *Pachistima* might readily have been derived from a type comparable either to that of *Celastrus* or of *E. japonica*. That is, the outer floral whorls may have become adnate first, then later become

adnate to the gynoecium with a turning outward of the unfused portion of the tube, or gynoecium and androecium may have become adnate before fusion of the outer whorls became extensive.

In *Euonymus americanus*, *E. atropurpureus*, *E. alata* and *Pachistima canbyi* very extensive adnation of floral traces was strongly evident. In all of them, the position of the carpel traces, especially the ventral carpel traces, strongly support the view that the limit of the extent of the stele is the point of departure of the floral traces beneath the base of the ovary.

As shown by quotations earlier in this paper, we note that the presence of recurrent receptacular or stelar traces is a clear cut criterion of an invaginated axis and a receptacular type of inferior ovary. If there were no question concerning the stelar nature of these recurrent traces, then this position would certainly be sound. Certain evidence from these studies, however, has impressed upon the writer that recurrent traces are not necessarily receptacular or stelar traces. He has been led to examine the evidence presented in support of this interpretation of their nature in several families considered to be notable exceptions to the appendicular rule.

In both *Euonymus alata* and *E. atropurpureus* it was observed that adnation of the dorsal carpel trace to the petal trace resulted in a slight, but noticeable, bending back of the dorsal carpel trace upon itself before it turned upward (Figs. 32, 35). Should such adnation proceed further, as it might well do, it would result in recurrent carpel traces strongly resembling the recurrent traces which have been considered to be stelar or receptacular, by Smith and Smith in the Santalaceae, by Jackson in *Rosa*, and by Smith (1928), in *Calycanthus*. A careful study of the evidence presented by these authors reveals that there are reasons to question their interpretation.

In *Darbya* and other members of Santalaceae, Smith and Smith (1942; 1943) have described the "recurrent receptacular traces" as giving off the so-called "x-traces" midway of the ovary as they pass downward. The x-traces, whose nature Smith and Smith consider to be in doubt, are clearly carpellary in the opinion of the present writer since they "move inward from the ring of traces and take up positions between the dorsal traces", and "swing inward at the top of the ovary and form anastomoses with each other just before the style is freed. A varying number of traces continue upward from these anastomoses to enter the base of the style". Yet the recurrent traces are interpreted as being receptacular, and are described as giving rise to the carpellary traces near their ends before they finally end in the pith of the stele. The writer, while not wishing to undertake a lengthy analysis of the situation in the Santalaceae in this paper, can not accept the interpretation that traces, which as described, clearly are carpellary, can originate midway of a "recurrent receptacular trace", and that the other carpellary traces originate at its lower end. This derivation of a trace into a carpel from a receptacular trace, before the carpel is given off seems inconsistent with morphological principles, as does their interpretation, previously mentioned, that vascular strands from a floral trace enter a receptacular disc in *Anacolosa*.

Furthermore, according to Smith and Smith, "directly opposite the sepals, *the traces to the outer ring and the inner inverted traces do not connect* (italics mine) at the top of the ovary as do the traces between the sepal positions. Instead they swing closer together to form what corresponds to a large compound amphicribral bundle with the individual traces rather loosely arranged. However, the outer and *inner traces remain distinct* (italics mine) and at the base of the floral tube each group becomes even more compactly arranged. The inner traces opposite each sepal give rise to a single inverted trace. Each of these traces then swings inward to enter the base of a stamen". A careful analysis of this description, or of the figures used to illustrate it, shows that the traces supplying the stamens do not connect at any point with the vascular cylinder of the stele, since this inverted trace ends blindly in the pith. Smith and Smith have recognized in their discussion the difficulties presented by the x-traces to the carpels and the stamen traces which do not connect with the stele. Of the former they say: "it is difficult to interpret the branch traces which extend inward from the inverted bundles and assume a position between the dorsal carpellary traces. There would seem to be three possible explanations: that they represent another whorl of organs, that they are median or secondary carpel traces or that they are merely anastomosing cross branches of no morphological significance. The third possibility seems most likely because of the anomalous position, large number and small size of the traces. On the other hand, these traces consistently appear in other genera of the family and may possibly have some significance not yet understood". Of the stamen situation they say: "there may also be very weak connections with the outer bundles." Yet they have previously said in their description, italicized by this writer, "*the traces of the outer ring and the inner inverted traces do not connect*," and "*outer and inner traces remain distinct*".

The writer feels that the interpretation of the so-called recurrent traces as receptacular traces is very much open to question, as is their apparent ending in the pith. From all descriptions given, the x-traces should be considered to be carpellary. It is interesting to note that where the inverted traces connect with the outer ring of traces, there are "strands of xylem-like sclerenchyma" continuing upward. It would seem quite possible to the writer that traces belonging to the suppressed petals of this flower are involved in the vascular picture, and that the traces which have been considered to be dorsal carpel traces are really median carpel traces. On this basis, the x-traces would represent the dorsal carpel traces.

Jackson (1934) has made a very strong case for the interpretation of the floral tube in most rosaceous flowers as consisting of the fused basal portions of sepals, petals and stamens. She bases her interpretation upon studies of vascular anatomy of various forms, in some of which floral traces are free from each other, and in others various degrees of fusion of floral traces are evident. The writer is in entire agreement with her interpretation.

After having given a clear picture of the processes of fusion by which the floral tube of most rosaceous flowers is formed, Jackson turns to *Rosa* and gives an entirely different interpretation, namely the invaginated axis, from evidence which clearly can be interpreted in the same way in which she interpreted the

other genera. Specifically, she shows in cross sections of the floral tube of *Rosa Helenae* Rehder and Wilson, three rings of bundles which she interprets as follows: "there are, thus, at this level (level 3 of figure 7) three circles of bundles, the innermost of which shows inverse orientation of the xylem and phloem elements (figure 10). These inverted bundles become connected with the middle whorl of bundles at various levels from somewhat above the level of insertion of the lowest carpel to somewhat above the level of insertion of the highest carpel. A section taken above the level of the highest connection of those two whorls of bundles shows the sepal-petal whorl of large bundles and within this a whorl of small bundles (figures 11, 7). The sepal-petal whorl supplies the sepals and petals. The inner whorl supplies the stamens. These stamen bundles branch freely in the upper part of the tube and the branches thus formed pass into the free stamen bases."

Miss Jackson might quite logically have interpreted her findings in *Rosa* as an advanced stage of the same thing she had previously found in other rosaceous flowers. All that she needed for this interpretation was to take the position that carpel traces are adnate to stamen traces up to varying levels, at which points they become free and bend back downward to the individual carpels. To support such an interpretation she had not only her evidence from other genera of the family, but also the fact that the stamen bundles here are obviously compound and that carpel bundles separate from them at various levels.

The writer certainly does not take the position that the above interpretation is necessarily the correct one, but he believes that from Jackson's own evidence it is a possible interpretation.

A study of the description and figures given by Smith (1928) for *Calycanthus*, leads this writer to believe that the same interpretation he has suggested for *Rosa* might be applicable to *Calycanthus*.

The principal point that the writer wishes to stress in this discussion of Santalaceae, *Rosa* and *Calycanthus*, is that we are told largely on the basis of the above cited work, that recurrent bundles are a clear-cut criterion of a receptacular inferior ovary. The writer can not accept this as being an established principle. How do we know that the bent bundles in *Rosa*, etc., are receptacular and not bent appendage traces which have fused? Is it not *possible* that toral reduction and adnation of floral organs occurring concurrently, produced recurrent *appendicular* bundles? Must we assume invagination of the torus rather than merely its extreme reduction? Have we any criteria on which to base the contention that recurrent bundles can not be appendicular?

The original objectives of this study were to determine if possible the nature of the tissue which taxonomic texts and manuals refer to as the disc, and its relationship to the superior or inferior nature of the ovary in this family. All evidence obtained from the species studied indicates that a distinction should be made in descriptions of these flowers between the floral tube, which is present in all of them, and the disc which is also present. In *Celastrus* the floral tube is quite obviously tubular, since it forms a cup in which the superior ovary stands free from the cup. Its tubular nature is less obvious in *Euonymus* and *Pachistima*,

where the ovary is adnate in varying degrees to the tube, and portions of the tube which are not adnate to the ovary form a flat expanse of tissue so often called the disc. The basic nature of the floral tube in the flowers studied differs in no fundamental respect from that described by Jackson (1934) for rosaceous flowers other than those of *Rosa*. The possibility that the same interpretation could also be applied to *Rosa* has already been discussed.

The disc which is present in the celastraceous flowers studied, occupies a position between the stamens, opposite the petals. In *Celastrus*, the disc and stamen bases form the lining of the cup around, but free from the ovary. Tissue of the disc extends upward from the inner rim of the floral tube as smal projections between the bases of the stamen filaments. The only definite evidence brought to light by this investigation which seems to indicate the nature of the disc, is the presence of very small, but quite definite, strands of vascular tissue which depart from both stamen and petal traces into the tissue of the disc between the stamens, in the position of the staminal whorl. The fact that these strands depart from what are quite definitely stamen and petal traces, seems clearly to preclude any receptacular interpretation of the disc. This leaves the possibility that the disc represents vestiges of floral parts no longer present. From its position, it seems best interpreted as representing bases of suppressed stamens.

The ovary in this family has been described by some as superior in the entire family, and as more or less inferior by others. If one were to accept either the definition of an inferior ovary as being "one that is adnate to the calyx", or a superior ovary as being one which is "wholly free from the receptacle", then the ovary in all species here studied would have to be considered to be superior. The ovary is certainly not adnate to the calyx, and is free from the receptacle except in that it occupies the apex of the pedicel. The writer believes that most botanists consider an ovary to be inferior if it is imbedded in other tissue, whether axial or appendicular. This view seems supported by the quotations given earlier in this paper concerning the rarity of the receptacular inferior ovary.

Granting that an ovary may be considered inferior regardless of the nature of the surrounding tissues, there is still the question of when to consider the ovary inferior, and when semi-inferior. Since the tops of most ovaries are not flat, it is not easy to decide what constitutes the limits of the top. This decision involves also the use of the terms epigynous and semi-epigynous. The writer has suggested the use of the levels of the top of the locules, which are easier to determine, in distinguishing between inferior and semi-inferior ovaries, in framing his definitions of the terms.

As defined in this paper, *Celastrus* has a superior ovary. This flower is also considered to be perigynous as that term has been defined here. The type of flower found in *Celastrus* is considered to be a step in the evolution of an appendicular type of inferior ovary. The flowers of all species of *Euonymus* studied, and those of *Pachistima* are considered to have semi-inferior ovaries and to be semi-epigynous. Thus the evidence from these studies suggests the view that this family has been correctly considered, on the basis of other evidence, to belong in a phylogenetic line culminating in strict epigyny.

Celastrus is considered to be the most primitive of the three genera studied, and *Pachistima* the most advanced. Several observations lead to this conclusion. In addition to the fact that adnation has not involved the gynoecium in *Celastrus*, it was observed that flowers with six stamens and six petals are not rare. On the other hand, *Celastrus* has a tri-locular ovary, whereas those of *Euonymus* have four or five locules. The ovary of *Pachistima*, which is considered to be semi-inferior, closely approaches the status of a completely inferior ovary. The ovary is bi-locular, but retains four dorsal carpellary traces. In *Euonymus*, the degree of adnation of floral parts to the ovary varies considerably. All species examined have semi-inferior ovaries, however. It is evident, and quite natural, that the evolution of different parts of the flower have not all proceeded at the same rate.

The trend which seems strongly apparent in this family, on the basis of the quite limited sample studied here, is an evolution proceeding from flowers with superior ovaries toward ones which have inferior ovaries. The basic underlying process which is bringing about adnation of floral whorls, in so many families, is thought to be a gradual condensation or foreshortening of the floral axis. The effect of such a process should ultimately, if carried far enough, produce a high degree of floral condensation upon which the writer finds it difficult to superimpose the idea of an invaginated axis which places the carpellary node at a level not only below (morphologically, of course, far above), but far distant from the other floral nodes. Thus he questions not only the evidence presented in support of the invaginated axis, but the theoretical basis for it.

SUMMARY

The vascular anatomy of the flower is described for two species of *Celastrus*, one of *Pachistima*, and four of *Euonymus*.

All species studied are considered to have a floral tube consisting of fused basal portions of floral whorls. In *Celastrus*, the floral tube is in the form of a cup surrounding, but free from, the superior ovary. The disc in *Celastrus* consists of tissue between the bases of the stamens, opposite the petals. On the basis of vascular strands, which depart from stamen and petal traces into the disc between the stamens, the disc is interpreted as consisting of basal portions of suppressed stamens. The floral tube in *Pachistima* and *Euonymus* is adnate to the base of the ovary in varying degrees. That portion of the tube not adnate to the ovary is turned outward forming a flat expanse of tissue around the ovary. The disc occupies the same position as in *Celastrus*, and is given the same interpretation.

The evidence for the interpretation of the floral tube in these flowers consists of very extensive fusion of floral traces. In *Euonymus atropurpureus* and *E. alata*, fusion of the dorsal carpel trace to the petal trace results in a bending backward of this trace. It is suggested that a similar but more extensive case of this may have led to the situation found in *Rosa*, *Calycanthus* and *Santalaceae* which have been interpreted differently by others. The evidence for interpreting recurrent bundles as stelar is questioned.

Definitions are suggested for the terms *disc*, *superior ovary*, *inferior ovary*,

epigynous flower and *hypogynous flower*. The terms *semi-inferior* ovary and *semi-epigynous* flower are suggested as useful descriptive terms.

Evidence from these studies seems to support the view that the family has been properly considered on other evidence to occupy a position in a phylogenetic line culminating in strict epigyny.

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EXPLANATION OF PLATES

PLATE 3

Celastrus orbiculatus Thunb.

FIG. 1. Reconstructed longitudinal section. Stippled areas are nectariferous; at left the disc, and at the right the base of a stamen. 1, ventral carpel trace; 2, petal trace; 3, vascular strand into the disc, exaggerated in size; 4, dorsal carpel trace; 5, sepal trace; 6, stamen trace; 7, median carpel trace. ×11.

FIG. 2. Tangential section. 1, separation of vascular strand from the petal trace. ×11. *Note:* Figure 2, and all subsequent figures of this and other plates, are camera lucida drawings of actual sections.

FIG. 3. Longitudinal section showing: 1, ventral carpel trace at base of locule; 2, median carpel trace showing branching in a septum. ×11.

FIG. 4–10. Cross sections through a single flower, all ×11. These are slightly oblique, being lower at the right than at the left:

FIG. 4. At the level of the anthers.

FIG. 5. At the top of the floral tube. 1, disc tissue between the bases of two stamens.

FIG. 6. Below the top of the floral tube. 1, sepal trace; 2, stamen trace; 3, petal trace. Note the numerous small vascular strands opposite most petal traces.

FIG. 7. Below the center of the locules. 1, origin of vascular strands from petal trace.

FIG. 8. At the base of the locules. 1, sepal trace; 2, vascular strand departing from stamen trace.

FIG. 9. Below the base of the locules. 1, divergence of petal trace and stamen-sepal trace.

FIG. 10. Close to point of departure of traces from the stele. 1, divergence of a second pair of petal and stamen-sepal traces; 2, one stamen trace not quite opposite the sepal trace and free from it above this level.

Euonymus americanus L.

FIG. 11. Flower fully open May 20, 1951. 1, petal; 2, disc; 3, sepal. The finely stippled area is nectariferous. Note the papillate surface of the ovary in the center. ×11.

FIG. 12. Flower after shedding anthers. Note that the filaments are now directed outward and the entire floral tube has begun to turn downward. 1, staminal cushion. ×11.

FIG. 13. Young fruit collected June 5, 1951. Note that the floral tube has turned downward. ×11.

FIG. 14. Stoma and guard cells of the apex of a papilla, or spine, on the surface of the ovary in the flower. ×1,520.

FIG. 15. Longitudinal section of bud two weeks before anthesis, showing separation of the dorsal carpel trace from the petal trace. ×8.5.

FIG. 16. The same bud as that in Figure 15. 1, separation of sepal and stamen traces; 2, ventral carpel trace; 3, separation of lateral sepal trace from petal trace. ×8.5.

FIG. 17. Cross section at the base of the locules. 1, sepal-stamen trace; 2, petal trace; 3, dorsal carpel trace; 4, base of a locule. Ventral carpel traces are seen in the center, ×11.

FIG. 18. Section below the base of the locules. Sepal-stamen traces departing from the angles of the star; carpel-petal traces from the points. Ventral carpel traces are in the angles of the star. ×11.

FIG. 19. Ten main traces turning outward from the stele. ×11.

FIG. 20. Cross section of the stele before the departure of the floral traces. ×11.

FIG. 21-27 (see also Fig. 28.) An ontogenetic series showing, in longitudinal section, changes in the position of the floral tube in relation to the ovary:

FIG. 21. Bud collected February 18, 1950. ×100.

FIG. 22. Bud collected March 17, 1950. ×100.

FIG. 23. Bud collected April 21, 1950. ×8.5.

FIG. 24. Bud collected April 29, 1950. ×8.5.

FIG. 25. Bud collected May 5, 1950. ×8.5.

FIG. 26. Flower collected May 12, 1950. ×8.5.

FIG. 27. Fruit collected June 5, 1950. ×8.5.

PLATE 4

Euonymus americanus L.

FIG. 28. Fruit collected September 16, 1950. Longitudinal section. 1, disc; 2, sepal; 3, stamen. ×8.5.

Euonymus atropurpureus Jacq.

FIG. 29. Median longitudinal section showing separation of the stamen and sepal traces, and the branching of the ventral carpel traces in the septa. ×11.

FIG. 30. Cross section of the pedicel showing the departure of seven traces from the stele. 1, stamen-sepal trace; 2, petal-carpel-lateral sepal trace. Note the large trace formed by the radial fusion of two traces comparable to numbers 1 and 2. ×11.

FIG. 31. Cross section at the base of the free part of the filaments. 1, stamen trace; 2, dorsal carpel trace; 3, median carpel trace (ventral carpel traces and branches which ultimately supply the ovules appear at the center). ×11.

FIG. 32. Longitudinal section of a bud five weeks before anthesis. 1, lateral sepal trace separating from petal trace; 2, point of departure of dorsal carpel trace; 3, point of departure of ventral carpel trace; 4, ventral carpel trace. ×100.

Euonymus alata Reg.

FIG. 33. Longitudinal section showing sepal-stamen traces. ×11.

FIG. 34. Slightly oblique cross section of the pedicel, showing eight traces departing from the stele. The trace at the lower right shows the separation of lateral sepal traces from a petal trace with which they are fused to the point of departure. ×11.

FIG. 35. Longitudinal section showing carpel traces departing from the carpel-petal-lateral sepal trace. 1 & 2, portions of ventral carpel trace (actually more connected with each other than this drawing shows); 3, dorsal carpel trace bending backward before it turns upward. ×100.

Euonymus japonica L.

FIG. 36. Cross section through the center of the locules. 1, petal; 2, stamen trace; 3, dorsal carpel trace. ×11.

FIG. 37. Cross section at the base of the locules. 1, dorsal carpel trace with median carpel traces on either side of it. ×11.

FIG. 38. Cross section at the base of the petals. 1, sepal; 2, petal trace with carpel trace opposite; 3, stamen trace. ×11.

FIG. 39. Cross section through the pedicel. 1, sepal trace; 2, carpel-petal trace; 3, stamen trace. ×11.

FIG. 40. Longitudinal section of bud showing carpel and petal traces. ×11.

Pachistima canbyi A. Gray

FIG. 41. Longitudinal section of a bud, showing separation of sepal, stamen and median carpel traces. ×100.

FIG. 42. Cross section at the level of separation of sepal, stamen and median carpel traces. 1, petal trace with dorsal carpel trace opposite; 2, sepal trace with stamen and median carpel traces opposite. ×11.

FIG. 43. Cross section of the pedicel at the point of departure of the eight floral traces. ×11.

FIG. 44. Longitudinal section showing separation of dorsal carpel traces from petal traces, and also ventral carpel traces at the base. ×11.

PLATE 3

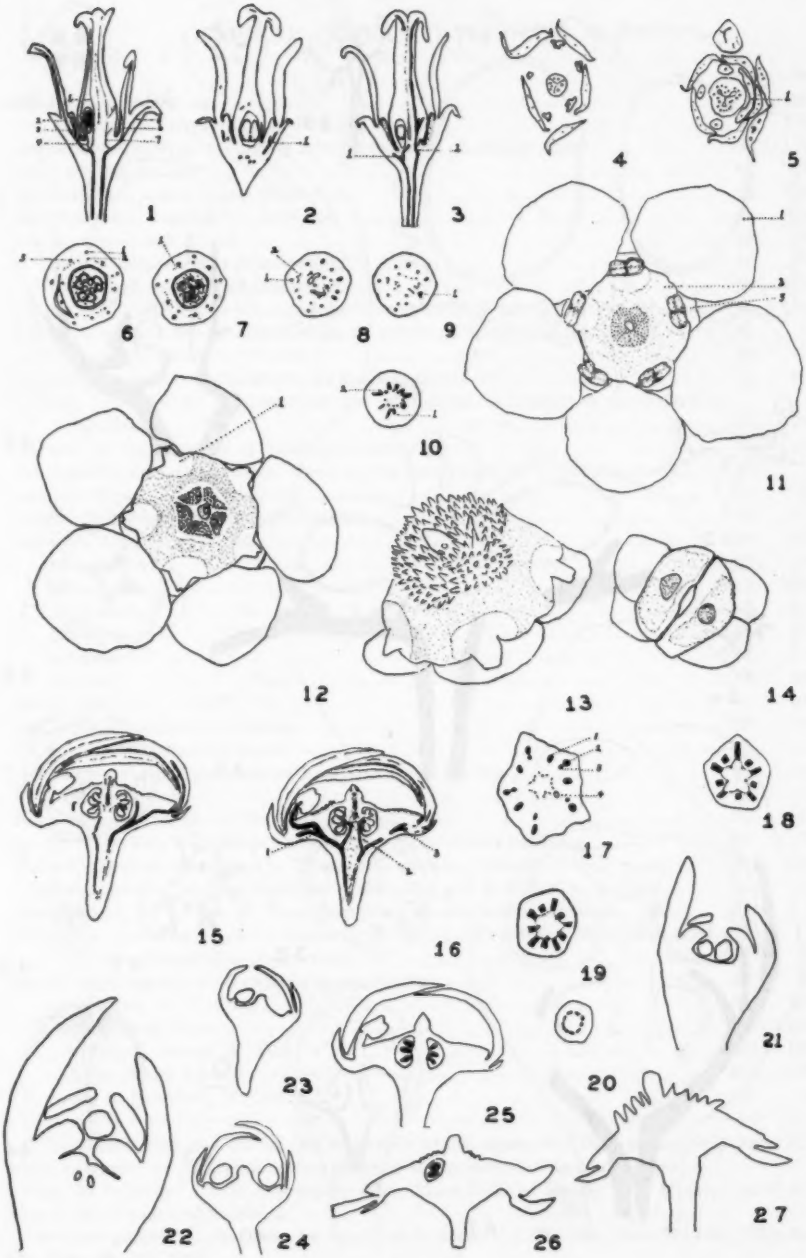
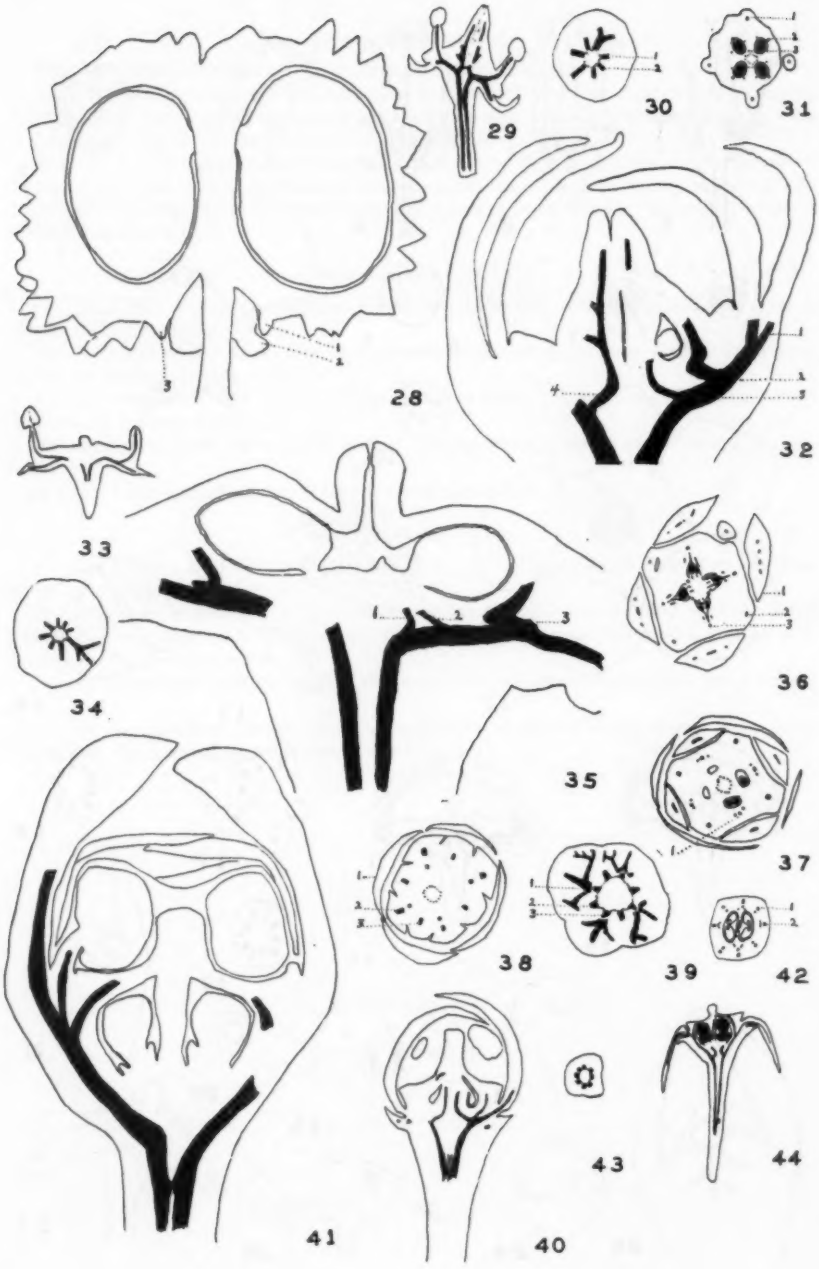


PLATE 4



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Vols. 59 to 67 no. 1 were indexed by Mrs. Alma Holland Beers; vols. 67 no. 2 to 69 by Miss E. Kathleen Goldie-Smith.

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